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A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES
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INFECTIOUS GRANULOMAS OF BONES AND JOINTS, WITH SPECIAL REFERENCE TO COCCIDIOIDAL GRANULOMA[1]

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OCCASIONAL infections of bone and joint, pathologically infectious granulomas, are caused by pathogenic fungi. They include blastomycosis, coccidial granuloma, actinomycosis, mycetoma, and torulosis. Because of their comparative rarity and resemblance, clinically and roentgenographically, to more common infections, they are readily overlooked. Diagnosis frequently comes as a surprise by recognition of the organism.

Presenting symptoms vary widely and cases will be seen by many kinds of medical workers. Positive diagnosis depends upon identification of the organism, therefore, upon general alertness, in order that this study be made. Proper cultures and animal inoculation are required, since the organisms are frequently not recovered by direct examination of discharges and tissues. Even on culture, the report is frequently "staphylococci" or "no growth." Repeated animal inoculation is sometimes required. Therefore, suspicion of mycosis should be readily roused and persistently followed. The roentgenologist will see cases properly studied and may aid diagnosis if there are criteria suggesting the diseases.

Our approach to mycosis of bone and joint must be through coccidioidal granuloma, 70 cases of which we have seen to date. Comparisons may be made with common infections, and attempted with other mycoses through the literature and our own few cases. The following description is made with reservation that the lesions observed are too few to include all types, and are particularly inadequate upon which to erect criteria for exclusion of the disease.

COCCIDIOIDAL GRANULOMA

By extension, lesions of bone may occur from adjacent primary infection of skin. A granulomatous node or intractible infection of skin develops to a slowly growing ulcer which may invade deeper structures. Lesions arising metastatically (the majority) may either arise in bone or invade it from adjacent soft tissue foci.

Origin in bone may be central or peripheral, epiphyseal or diaphyseal, in a region of cancellous bone. One lesion arising in tubular bone is not positively established. Peripheral lesions may rise subperiosteally or by extension from soft tissue. Except in the hand and foot, lesions by extension appear also to elect spongy bone. Spread to bone at ligamentous and tendinous attachments may partially explain a "bony prominence" predilection, later to be mentioned. The

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

origin of advanced lesions is often not determinable.

Osseous involvement is predominately destructive, complete, or a partial "permiation." Margins of lesions may be "punched out" or diffuse.

Bone production is variable: many foci have none, some have it marginally, and a few have it within the focus of destruction. Rarely it predominates. The one sclerosis seen is so at variance with all the others that it cannot be accepted on the fact that it occurred in a proven case. Early or rapid lesions tend to partial destruction without production; chronic ones, to complete central destruction, marginal osteogenesis, and circumscribed borders. The infections are intractible, may halt, but seldom retrogress. Efficient healing is exceptional, but has been seen after intensive treatment by colloidal copper, vaccine, and vigorous supportive measures, as, for example, a tarsal area completely excavated and bounded by smooth marginal cortex; regeneration of cervical spinous processes; osseous repair of the tubercle of a tibia; apparently complete arrest of an advanced involvement of an ankle, giving a classical appearance of healed tuberculosis; complete bony ankylosis of an ankle (Fig. 1-*B*).

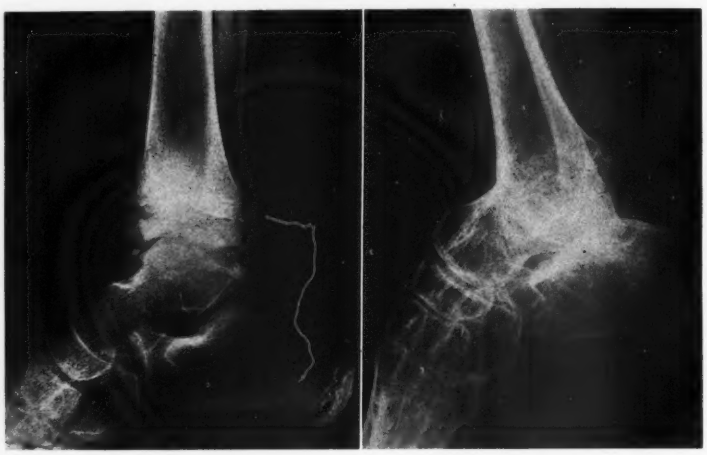


Fig. 1-*A*.

Coccidioidal granuloma, chronic, responding to treatment. *A*. Early lesion in the metaphysis of the tibia.

Fig. 1-*B*.

B. After extensive destruction there was repair and complete bony ankylosis. Advanced chronic atrophy.

Productive periostitis occurs frequently, but not necessarily, with superficial involvement of bone. It is very variable in amount, usually scant, resembles that of similarly located tuberculosis, and occasionally profuse, particularly after operative intervention or with mixed infection. It is more marked in chronic cases and those with much soft part involvement. Periosteal bone is seldom smooth and well organized, but remains irregular and incomplete. It is without parallel lamination, but frequently shows perpendicular striation. The lower extremity of a humerus, after curettage, developed profuse periostitis, with perpendicular striation, extending far up the shaft (Fig. 2). Periosteal production is slow and late, as a rule, compared with osteomyelitis.

Cystic appearances are seen, single or multilocular, circumscribed by more or less well organized bone, as described by Jüngling (13) in tuberculosis, by Bromer (3) in osteomyelitis, and by Murdock and Hutter (17) in leprosy. These are most

typical in cases responding to treatment. The trabeculæ may be thick and irregular, as described by Bromer (3) for osteomyelitis, or slender and well defined as in tuberculosis or osteitis fibrosa.

Lesions are usually multiple eventually, but a single lesion is often noted on first examination.

Epiphyseal cartilage and articular structures are an incomplete bar to extension.

Rapidity of advancement is very variable but slower than acute osteomyelitis, requiring several weeks or months for a display of progress on the film. Nonperiosteal bone production is particularly slow.

Associated soft tissue swelling usually occurs with peripheral lesion, varying from slight to extreme.

Joints are usually involved from adjacent infection of bone or soft tissue. Infection may burrow extensively beneath the articular cartilage before it is destroyed and the joint visibly involved. Early articular involvements have occurred and a few which appeared primary, including two knees and a wrist. The only roentgen evidence of involvement may be excess articular fluid. Wandering joint pains are frequent in early general invasion before metastatic lesions are demonstrated, without evidence, then or later, of involvement of these joints. In such cases pulmonary involvement, presumably primary, is usually present.

A survey of 43 joints was made, giving attention to points used by Phemister (18, 19) in his comparison of tuberculous and infectious arthritis. Vertebral and sternoclavicular joints were excluded as not affording sufficient detail.

In 20, involvement appeared predominately osseous; in 10, general; in 13, predominately articular, and in 4, purely arthritic, without destruction of bone, except the articular cortex. Since the majority of all lesions are purely osseous and those which involve joints are not predominately articular, this predilection appears contrary to that of tuberculosis.

Destruction of cartilage as determined by a narrowed articular interval in 11 cases was general; in 11, opposite bone destruction; in 3, localization at a weight-bearing point might be inferred; in none was it evident at non-contacting regions of cartilage. In 18 there was no narrowing, due either to early involvement or to late lesions, with an increased articular interval.

Erosion of articular cortex in 15 cases was general; in 17, definitely adjacent to local bone destruction; in 2, a weight-bearing region appeared elected, and in 3 a non-contacting region of the joint. In 6, there was none.

The only clear predilection shown is to destruction of articular cortex and cartilage adjacent to bone destruction. No roentgen inference is seen of selective destruction of non-contacting cartilage, of selective preservation of weight-bearing cartilage, or of erosion of cortex beneath a dead but preserved cartilage, as demonstrated by Phemister in tuberculosis. He describes a secondary osseous extension from tuberculous arthritis, featured by invasion of both opposing bones. No tendency was seen to this symmetrical bilateral involvement in our cases. This appears to strengthen somewhat the conception that the lesions are primarily osseous.

No selective destruction of cartilage at weight-bearing points is seen in our cases, as described by Phemister in infectious arthritis.

Sequestra were seen at two joints, one probably in the suprapatellar sulcus of a knee, and two not certainly in a joint. These were separated from the bone, their origins not determinable. Opposed juxta-articular sequestra, described by Phemister in tuberculosis, appear not common.

Marginal grooving, described by Phemister in tuberculosis, was not seen. A slight marginal erosion of articular cortex in five cases may indicate a minor tendency to this manifestation of tuberculosis. Hypertrophic marginal lipping as found in hypertrophic arthritis deformans and late infectious arthritis was not seen.

Fig. 2. Coccidioidal granuloma. Extensive profuse periosteal production following curettage of a small focus in the lower extremity of the humerus. Extensive destruction of tubular bone which is unusual in this disease.

Fig. 3-*A*.

Fig. 3-*B*.

Coccidioidal granuloma. *A*. Typical lesion at the tubercle of a tibia. *B*. Complete healing of this osseous lesion. Advanced chronic atrophy.

Regional atrophy of spongiosa was present in all but one early case, varying greatly, averaging moderately advanced. Atrophy of nearby tubular cortex was present in 21 cases (about half), averaging slight. This appears to differ from tuberculosis and to be attributable to a more acute course, briefer, more complete disuse, causing acute decalcification of spongiosa with less of the slower atrophy of tubular bone. Two cases responding to treatment had well organized chronic atrophy of cancellous and tubular bone, squared epiphyses, and fusiform enlargement of joints, giving the classical appearance of tuberculosis (Fig. 3-*B*).

A statement in our previous paper requires modification; "Atrophy of disuse or of bone adjacent to involvement was not pronounced except in a few lesions of the wrist and ankle" (5). There is moderate atrophy, less pronounced, but similar to that of infectious arthritis.

Osseous lesions unassociated with joints caused no regional atrophy.

Soft tissue swelling about the joint was present in all but three cases. Swelling within the joint could be studied only where differentiating shadows are available, as at the knee and ankle. It was evident in 17 cases, in 6 not. It usually resembled that of infectious arthritis. In two cases it was fusiform, as in tuberculosis.

Articular swelling was a sole evidence of involvement in a few cases, other manifestations either never appearing or so long delayed that it may have been reactive only.

Peri-articular periostitis was evident in 24 of 43 cases, averaging slight, its characteristics as previously described.

Regional Survey.—All bones, except the facial bones, have been involved. There is a predilection to so-called bony promi-

nences, as, the malleoli, tubercle of the tibia, the patella, extremities of the clavicle, angles, acromion and coracoid processes of the scapula, lesser trochanter of the femur, epicondyles of the humerus, olecranon and styloid processes of the ulna, styloid process of the radius. This appears to differ from non-mycotic infections.

All joints have been seen involved, except the shoulder joints proper, and the temporomandibular. Those most frequently involved are, in order: the ankle, knee, phalangeal, tarsal, carpal, and elbow. One of each, a hip, acromioclavicular, sternoclavicular, and sacro-iliac joints, were affected. The sparing of hip and shoulder is unlike tuberculosis and infectious arthritis.

Lesions at the Knee.—Most frequent is a destruction starting at the tuberosity of the tibia (Fig. 3), eroding directly through the bone, readily crossing the epiphyseal line of the tuberosity, fused or unfused, but not readily crossing the upper epiphyseal line, fused or unfused. The joint is usually involved late, if at all. Some apparent involvements appear due to swelling beneath the ligamentum patella without articular invasion.

Infections of the patella are next most frequent, starting at the upper or lower margins, anterior surface, or centrally. These invade the joint earlier than the tibial lesions but an osseous origin is usually clear. Periostitis occurs if the anterior surface of the patella is involved.

A few cases, either arising in the knee joint or invading it early, have been recognized since our former survey. These are particularly like tuberculosis, and are a small minority. One case showing articular swelling only had synovectomy under diagnosis of tuberculosis. Excised synovia revealed no tubercle bacilli, and *Coccidioides immitis* were found. Recovery followed operation and administration of colloidal copper and coccidioidin vaccine. No recurrence was evident at last report.

The ankle.—Most lesions start in the malleoli, at their tips, superficial surfaces, or, less often, centrally (Fig. 4). Adjacent bone is invaded; the joint is usually involved after a considerable destruction of bone. There is usually scant irregular periosteal proliferation. One lesion rose in the anterior margin of the metaphysis of the tibia, invaded the joint, with eventual advanced general destruction, very tuberculosis-like, but ending in complete bony ankylosis (Fig. 1). One infection extended to a malleolar tip from adjacent tarsal involvement.

Fig. 4. Coccidioidal granuloma. Extensive destruction at the base of a tibial malleolus, local erosion of articular cortex, no destruction of cartilage.

Tarsal lesions appear almost exclusively osseous in origin, the infection frequently of the scattered destructive and productive type resembling osteomyelitis (Fig. 5). With any degree of advancement adjacent joints are involved; soft part swelling is marked; regional atrophy marked and of acute type. The os calcis is most frequently involved.

Involvement in metacarpal, metatarsal, and phalangeal regions appears to arise in joints more frequently than elsewhere. Bone was always involved, usually with marked periostitis resembling the dactylitis of osteomyelitis, syphilis, and, to less extent, that of tuberculosis (Fig. 6). Cystophorous involvement, with expansion of bone like that of tuberculosis, was not seen in these regions (12).

Wrists.—Involvement rose at the adjacent lower extremities of radius and ulna, particularly at their styloid processes; at the base of a metacarpal bone, or within the carpus. The radiocarpal and the carpal joints were readily involved. Osseous involvement within the carpus was purely destructive. One infection appeared primarily articular, showing erosion of articular cortex but no visible bone destruction otherwise.

Hip.—Only one lesion of the hip joint was seen, and that was peculiar. The first film to show pathology revealed complete dislocation without evidence of bone destruction or erosion of articular cortex. The condition of the cartilage was not revealed. Without history, traumatic dislocation would be diagnosed. The involvement appears purely articular. One destruction at a lesser trochanter was seen. Lesions about the hip are conspicuously rare in this series.

Shoulder.—Clavicles are involved at their extremities, with or without evident invasion of joint. Scapulæ are involved at the inferior angle, vertebral border, and at acromoion and coracoid processes. The shoulder joint proper was not involved.

Elbows are attacked at the condyles of the humerus, olecranon process of the ulna, and in juxta-articular epiphysis. The elbow joint appears less readily involved than most (Fig. 7).

Fig. 5. Coccidioidal granuloma, tarsal lesion. Much bone production, early involvement of adjacent joints, marked acute regional atrophy.

Skull.—Circular or irregular, purely destructive circumscribed lesions involve the outer table or both tables. Sometimes only the superficial part of the outer table is destroyed. The diameter of the destruction may be greater in the outer table, but the reverse is not seen. Subperiosteal abscess without bone destruction occurs. Superficial osteal origin is thus inferred (Fig. 8).

Ribs are involved by two main types of lesions, both purely destructive and without periostitis. The majority are "bitten out" marginal foci, the minority central foci. Occasional extension occurs to the rib from adjacent infections of the spine or from perivertebral abscess (Fig. 9).

Lesions of the *sternum* are usually super-

Fig. 6. Coccidioidal granuloma, metacarpo-phalangeal lesion. Marked periostitis.

Fig. 7. Coccidioidal granuloma at the elbow. Central lesion in the lateral epicondyle of the humerus, slight periostitis, no invasion of the joint.

ficial destructions, obviously extended from soft part lesions.

Vertebræ are attacked indiscriminately in bodies, neutral arches, transverse and spinous processes (Fig. 9). Erosions of anterior margins of vertebral bodies occur, usually involving several. Some bodies may have wedge deformity as in tuberculosis. Some have central circumscribed destructions, solitary or multilocular without collapse. The intervertebral cartilage may or may not be affected.

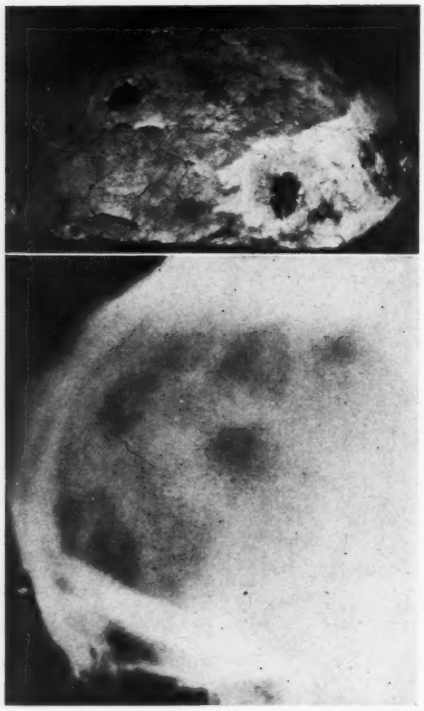
The *pelvis* has central lesions of cancellous bone, like those seen elsewhere, usually multiple. A sacro-iliac joint in our file has localized involvement with a small destruction of adjoining bone, similar to tuberculous involvements of that region. I have been shown a film of a similar lesion by Dr. Jacobson.

Altogether a bizarre group of lesions is presented. Surveyed as a group the multiplicity, peculiar locations, and types of involvement are distinctly at variance with commoner diseases affecting bone and joint. A single lesion without associated manifestations may have nothing to suggest mycosis. A solitary central osseous focus appears particularly obscure. However, this has seldom been a sole first manifestation. Lesions as described for the ankle, knee, skull, bony prominences, and spine, however, even singly appear legitimate grounds to suspect the disease.

Multiple lesions of bone and joint are apt to have an assortment at least highly suggestive of, if not incompatible with, non-mycotic disease.

Associated manifestations other than of bone and joint are usually present and of diagnostic aid.

Many cases have a pulmonary onset from which recovery, if it occurs, is slow and incomplete. With or without this history, the film usually shows enlargement of hilar and mediastinal glands and pulmonary lesions, tuberculosis-like, more resembling the juvenile type—vague, par-



Figs. 8-*A* and 8-*B*.

Coccidioidal granuloma of the skull. Note the greater diameter of the lesions in the outer table (*A*), and involvement of the outer table (*B*), not yet penetrating the inner table.

tial consolidations which may come and go, miliary infiltrations, less clearly defined than in tuberculosis, widespread patchy involvement as in a "bronchopneumonic" tuberculosis. Appearances like classical adult tuberculosis, with peripheral subapical accentuation, linear streaking of fibrosis, air-containing cavities, descending bronchogenic spread, clustered nodular involvements, have not come to autopsy proof. One such appearance supervening in known coccidioidal granuloma proved at necropsy to be due to coincident tuberculosis. One such pulmonary appearance remains as probable coccidioidal granuloma. The *Coccidioides immitis* were recovered by animal inoculation from the sputum, which was repeatedly negative for the tubercle bacillus. A film of the chest is essential in any case of obscure lesion of bone or joint.

Cutaneous involvements are common; warty granulomatous nodes, ulcers with granulomatous bases and undermined edges, persistent sinuses from deeper foci, or rarely a general pustular eruption. A node may be painless and inconspicuous, attracting attention only by ulceration while under observation.

Local lumpy fluctuant subcutaneous abscesses, unassociated with bone, are frequent.

Glandular enlargements, widespread or local, may be seen. Cervical adenopathy is common. In the chest, hilar and mediastinal enlargements are especially frequent. Large abscesses of retroperitoneal glands may deform the psoas shadows on the film of the abdomen.

Symptoms of general infection and intoxication may be present, including loss of weight, strength, and appetite; fever; night sweats; leukocytosis; wandering rheumatoid pains, and anemia.

Symptoms of meningitis may supervene, like those of tuberculosis. A meningeal termination is frequent in mycoses and is not a diagnostic point favoring tuberculosis. In the fulminating form it may occur early with only pulmonary involvement and inconspicuous lesions in skin, soft tissue, bone, or joint.

Almost any conceivable combination of manifestations may occur. Some are apt to be less consistent with the usual nonmycotic diseases. For instance, central lesions of spongiosa consistent with tuberculosis, Brodie's abscess, or neoplasm may combine with a malleolar involvement or cranial foci.

SYSTEMIC BLASTOMYCOSIS

Similar regions of the same bones have involvements strikingly alike. Similar lesions of long bone, ribs, spine, and cranium are seen. The classic description of Potter appears to apply almost equally well to both diseases (21).

Fig. 9. Coccidioidal granuloma of the spine. All parts indiscriminately involved; extension to adjacent ribs

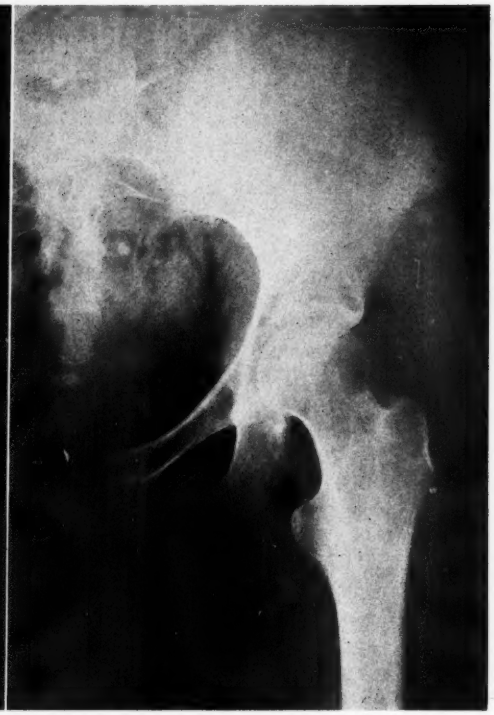


Fig. 10. Actinomycosis. Superficial invasion of an iliac bone from a massive adjacent soft tissue lesion; productive periostitis; calcareous bodies in the soft tissues.

Both usually involve joints secondarily. Stober says of blastomycosis: "In those necropsies in which opportunity was afforded to study changes in and about the joints communication with abscesses in the adjacent bone were always found," and, "extension by rupture of the epiphyseal abscesses was responsible for a majority of the joint lesions" (21).

The following descriptions of blastomycosis illustrate similarities:

"An abscess two inches in diameter . . . communicating with a region of softening in the parietal bone an inch in diameter, involving almost its entire thickness. An irregular perforation 8 mm. in diameter existed in the inner table exposing the dura mater." (Churchill and Stober, 7).

"The epiphyses of the lower end of the tibia and fibula also contained small yellowish softened areas communicating with abscesses over both malleoli which had ruptured externally." (Lewison and Jackson, 14.)

"Lesions developed in the following bones: Multiple lesions of the bones of the vault of the skull involving both tables; the right acromion process; medial ends of both clavicles and the manubrium; condyles of the right humerus; upper end and shaft of the right ulna; styloid process of the right radius; lower end and condyles of the left humerus; styloid process of the left radius; crests of the iliæ; the right greater trochanter; middle third of the left femur; lower third of the right femur; upper poles of both patellæ; right tibial tuberosity; right medial malleolus; distal ends of both first metatarsals, and a marginal lesion of the eighth rib." (Gaspar, Fenstermacher, and Lingeman, 11.)

The last quotation is made at length because the numerous involvements cited and their accompanying illustrations ap-

pear classical for coccidioidal granuloma, with one exception. Where we have only one debatable lesion arising in tubular bone, this case of blastomycosis has several.

to consider the common characteristics of the two diseases as those of a "typical systemic mycosis" and to compare commoner infections and other mycoses with them.

Fig. 11. Actinomycosis. Local destruction in the right pubic bone; marked spreading of the symphysis; apparently primary in bone or adjacent soft tissue.

Cystophorous lesions have been seen in our cases of coccidioidal granuloma and in blastomycosis appear to be shown in various illustrations of blastomycosis, for example, lesions described by Raiford (20) as "multiple shotty dissolution of bone."

Both diseases have similar associated manifestations: frequent pulmonary onsets, constitutional symptoms, subcutaneous abscesses, cutaneous nodes, ulcers, sinuses, pustular eruptions, and meningeal terminations.

Systemic blastomycosis has more spontaneous remissions and is more amenable to treatment, particularly by iodides.

Coccidioidal granuloma, however, has responded to extra-intensive iodine treatment, Ball (1), Grey (5), Jacobson (personal communication).

Altogether, the two systemic diseases as described by various authors appear not to differ more than would the observations of men reporting on different cases of the same disease. It may be proper

ACTINOMYCOSIS

Actinomycosis is frequently primary about the mouth and in the gastro-intestinal tract, particularly at the cecum, while coccidioidal granuloma has a few primary invasions of the oral region and none in the lower gastro-intestinal tract. Gastro-intestinal invasion is also significantly missing in autopsy reports of blastomycosis. Pulmonary actinomycosis is frequent, but with a greater tendency to pleural lesions with fibrosis, and to perforation through the chest wall. Miliary infiltrations appear less common.

Osseous involvement appears less common and more apt to extend from a single massive soft tissue lesion (Mattson, 16). One case showed extensive superficial involvement of an iliac bone adjacent to a massive actinomycotic lesion, presumably arising at the cecum (Fig. 10). There appears a greater tendency to profuse periosteal ossification in keeping with the more

chronic character of the disease. Local central lesions of cancellous bone appear less frequent, also invasion of the joints and evidence of widespread metastases. We have, however, one case of a lesion apparently primary in a knee and one arising at the syphysis pubis (Fig. 11). One lesion at an ankle resembles somewhat our coccidioidal cases, but with extreme periosteal proliferation (Fig. 12). In two cases there were small oval calcareous shadows in involved soft tissues not seen in coccidioidal granuloma, tuberculosis, or in descriptions of blastomycosis I have encountered. One chest had numerous small calcareous nodules, a few millimeters in diameter, in the lung-fields, similar to those in tuberculosis with fibrosis and calcification, but without the usual parenchymal manifestations seen in that disease.

Fig. 12. Actinomycosis, by inoculation from a local cutaneous injury. Marked periostitis, diffuse productive and destructive lesion of the os calcis.

Actinomycotic lesions of the spine (Fig. 13) are frequently reported resembling those of blastomycosis and coccidioidal granuloma (Tabb and Tucker, 22). All parts of the vertebræ are involved. The lesions in the vertebral bodies are frequently sharply punched out, and without collapse, a type only unusually seen in tuberculosis (22). Actinomycosis appears to resemble blastomycosis and coccidioidal granuloma in absence of a predilection for articular structures, and in invasiveness.

TORULOSIS

Torulosis shows marked predilection for meningeal and cutaneous involvement, and skeletal infections are rare. We have been privileged to study one case, that of Dr. John C. Wilson, which will be reported by him. A local lesion, apparently arising

Fig. 13. Actinomycosis. Collapse of a vertebral body; anterior erosion of several vertebral bodies.

in the condyle of a femur, produced a large granulomatous mass of neoplastic appearance, involving bone, articular structures, and overlying skin (Fig. 14). This lesion showed a marked invasiveness, a feature frequently seen in mycoses. Comparisons cannot be made otherwise. A pulmonary lesion was present, somewhat resembling classical tuberculosis.

MYCETOMA

Mycetoma (*Madurafoot*).—A chronic diffuse infiltration of tissues, usually of a foot, by one of several varieties of ray fungi, but it is a disease distinct from actinomycosis. In characteristic advanced form the foot is tremendously swollen and has numerous sinuses. The universal permeation of tissues may leave bones diffusely destroyed, and barely visible on the film (Fig. 15). It is locally invasive, with no tendency to systemic spread.

TUBERCULOSIS

Both diseases have local destructions of spongiosa, independent of articular involvement. Both usually have some subperiosteal bone production if involvement reaches the periphery. Purely osseous involvement is a minor manifestation in tuberculosis, a major one in coccidioidal granuloma and blastomycosis. Bone production within the lesion is more scant in tuberculosis. Both may have bone production, particularly with the associated pyogenic infection, common in both diseases after sinuses are established: there appears little distinction in this type of osseous lesion in the two diseases. Coccidioidal granuloma has a bony prominence predilection, greater multiplicity, is more rapid, and has a much higher incidence of cutaneous nodes and ulcers.

Involvements of joints may in either case be purely or predominately articular. This is a minority manifestation in coccidioidal granuloma, a common or major one in tuberculosis. Destruction of juxta-articular bone is usually less pronounced and later in tuberculosis. Both spare articular cartilage more than infectious arthritis. In coccidioidal granuloma, one does not see destruction at non-opposed cartilage, juxta-articular sequestra, or marginal grooves. Lesions at tubercles of tibia, at the malleoli, or at other bony prominences are not common in tuberculosis. However, we have seen two tuberculous involvements arising at malleoli tips which resemble closely our coccidioidal ankles (Fig. 16). The same joints are affected in both diseases, except that involvement of hip, elbow, and shoulder joints appears less common in the mycosis.

The evolution of tuberculous arthritis is usually slower, requiring years to reach the degree of advancement which coccidioides reaches in a few months. Correspondingly, regional atrophy of tubercu-

losis usually is chronic, with complete rearrangement of cancellous structure and narrowing of tubular bone and wasted muscles so that these joints display the classical "fusiform swelling." Coccidioidoses show, on the contrary, a more marked, more acute atrophy, with acute irregular decalcification of cancellous bone, acute soft tissue swelling, but less general wasting of muscles. Chronic coccidioides, partially arrested for years, has given the classical general appearance of tuberculosis (Figs. 1-*B* and 3-*B*).

Tuberculosis has its more acute cases, with multiple lesions of skin, bone, and joint, in which no ready roentgen distinction is evident. Such appear to be Cases 14 and 15 of Lovett and Wolbach (15), upon which they comment "curious punched-out lesion of the skull was identified pathologically in two cases as being definitely tuberculosis." Case 15 particularly appeared mycosis-like.

Tuberculosis of the tubular shaft, with its predominantly productive reactions and obvious periostitis, discussed by Bromer and Downs (4), has not been closely imitated in our cases of coccidioidal granuloma. The possibility of such involvement cannot be excluded.

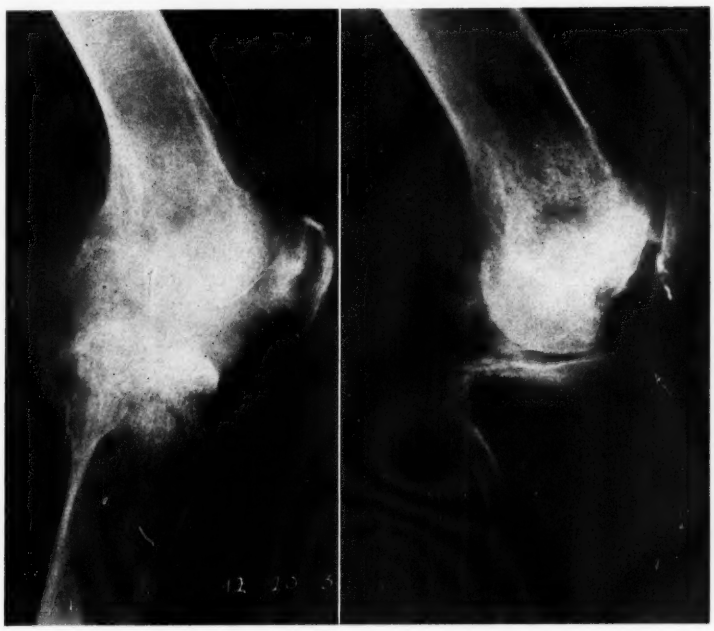


Fig. 14. Torulosis. Destruction starts in bone near the joint, very invasive, producing a large granulomatous mass.

It is believed that the roentgen characteristics of coccidioidal granuloma are present in only a minority of tuberculous lesions, and, when present, the chance of mycotic infection is so increased that the possibility is worthy of report. This is certainly true in a region where a mycotic infection is endemic. The possibility is definitely heightened in the adult when pulmonary lesions as above described are also present.

LEPROSY

Leprous osteomyelitis affects the bones of the hands and feet almost exclusively (Murdock and Hutter, 17). An indi-

Fig. 15. Mycetoma. Diffuse invasive infiltration; bones grossly destroyed and decalcified throughout.

vidual lesion might resemble coccidioidal granuloma closely. The very chronic course of leprosy, alternating improvement and advancement, and the associated trophic changes of "nicking," "slicing," "collar-buttoning," or gradual disappearance of terminal phalanges, is unlike infections and the mycoses (Chamberlain, Wayson, and Garland, 6).

A cystophorous type of leprous osteitis is frequent (17), which appears to resemble most closely that of tuberculosis.

OSTEOMYELITIS

The usual osteomyelitis differs widely from coccidioidal granuloma. A comparable focal coccidioides occurs: it has less bone production, does not readily heal, does not extend readily to tubular bone, has not massive sequestra, involucra, or widespread hyperemic decalcification, is less acute, and may have associated manifestations of mycosis.

The osteomyelitis of Garré differs radically, and is simulated by only one unproven sclerosing lesion.

Brodie's abscess in an epiphysis or cancellous diaphysis may be indistinguishable. It is less often multiple, is less invasive, is less prone to attack "bony prominences," has no mycosis-like associated symptoms, and less readily invades adjacent joints.

A cystophorous lesion may be seen in either disease.

We have no cystic coccidioidal lesion resembling closely the case of osteomyelitis illustrated by Bromer (3).

INFECTIOUS ARTHRITIS

In infectious arthritis, primary in the joint, the cartilage (Phemister, 18) is narrowed early by protiolytic digestion, accompanied only by erosion of articular cortex, and accentuated at weight-bearing points. If severe, the destruction of cartilage will be general and rapid. Clinical symptoms are more severe. Repair is earlier, associated with fibrous or bony ankylosis. Marginal exostosis, frequent in later stages of infectious arthritis, is not seen in coccidioidal granuloma.

Infectious arthritis by extension from an adjacent epiphyseal osteomyelitis resembles coccidioidal granuloma more closely. Here also the course is more rapid and cartilage is more quickly destroyed. Juxta-articular sequestra are more common, and repair occurs, with bone production. Ankylosis or marginal exostosis may be present.

SYPHILIS

Congenital syphilis whose principal effects are at epiphyseal cartilage and adjacent diaphysis should only occasionally be simulated. Acquired proliferative syphilis of bone, with irregular sclerosis, marked periostitis, and ready involvement of tubular bone, appears fundamentally unlike coccidioidal granuloma. Local

gummata may resemble coccidioidal granuloma on the film. More bone production and periostitis would be expected, but would not be conclusive. Syphilis of the clavicle readily involves its tubular region and is not limited to its extremities.

In all cases, the more indolent course, more bone production, periostitis, frequent regressions, serologic reaction, clinical symptoms, and response to treatment should indicate syphilis.

COMMENT

Skeletal mycotic infections appear by group survey to resemble each other more than the common infections, tuberculosis, pyogenic infection, and syphilis. They resemble tuberculosis more closely than the other two. Coccidioidal granuloma and blastomycosis are very similar.

What may be termed "mycotic predilections" include lesions solitary rather than scattering; selective involvement of spongy bone; articular lesions obviously extended from bone; local infections intractible to conventional treatment; multiple foci, including non-skeletal ones, cutaneous, subcutaneous, glandular and pulmonary, from which ready blood vascular dissemination is inferred; invasiveness greater than in most infections but, in spite of this, less tendency to involve tubular bone. The more acute widely disseminated tuberculous involvements are particularly mycosis-like. Punched-out lesions of the skull, involvements of spine not limited to vertebral bodies or intervertebral discs, and intrathoracic infections which penetrate the chest wall are particularly suggestive.

These so-called mycotic characteristics have little or nothing pathognomonic. Group differences are readily erected but it is difficult to present positive points of distinction. Where single lesions are presented there may be little or nothing to suggest mycosis. Where foci are multiple and varied a tentative diagnosis may be justifiable. Positive diagnosis does not appear available on the film. It appears pertinent to cite the warning of Lovett and Wolbach (15): "The diagnosis of infectious lesions of bone would be simple if each infectious agent always produced the same reaction."

Fig. 16. Tuberculous osteomyelitis arising at a malleolus closely resembling that of coccidioidal granuloma. No articular invasion.

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LYMPHOBLASTOMA: A GENERALIZED DISEASE[1]

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A COMPLETE discussion of the various manifestations of lymphoblastoma is, of course, impossible in a presentation of this kind. I shall, therefore, only attempt an outline of the general course of the disease, with a more detailed discussion of the roentgen findings in some of the organs where it is frequently overlooked.

The term "lymphoblastoma," as suggested by Mallory, has recently been defined and elaborated by Viets and Hunter. The classification which they suggest seems to me to be the best yet published, and is a definite advance in clearing up the confusion of terminology found in the literature. In their classification, such terms as lymphosarcoma, Hodgkin's disease, lymphogranulomas, pseudoleukemia, lymphatic leukemia in its aleukemia form, and the skin manifestations of lymphoblastoma, mycosis fungoides, are grouped under the general term "lymphoblastoma."

A qualifying clinical term is added to distinguish the various forms, thus: lymphatic leukemia, becomes lymphoblastoma leukemicum; aleukemic lymphatic leukemia, lymphoblastoma aleukemicum; mucosis fungoides, lymphoblastoma cutis; Hodgkin's disease, lymphoblastoma (Hodgkin's type), and lymphosarcoma, lymphoblastoma (infiltrating type). There are many cases on record of leukemia becoming aleukemia or even pseudoleukemic, and of Hodgkin's disease showing sarcomatoid infiltration of the skin, like those of mycosis fungoides. This broad method of classification should lead to a better understanding of this group of diseases.

Lymphoblastoma may then be described as a progressive generalized disease, almost invariably fatal, occurring at any age, in either sex, and involving any tissue of the body, although it is primarily in the glands of the neck and mediastinum. It may, or may not, be accompanied by changes in the blood cells. Occasionally, it is rapidly fatal; more often it runs a chronic course. The response to irradiation is usually prompt and striking; the masses disappear rapidly under adequate treatment and often do not recur in the same location. In the early stages of the disease, the patient recovers his strength and ability to work after each treatment. As the disease progresses, recovery is less definite and eventually fails completely; at this time there is usually involvement of the liver, and the patient may develop a temperature, ascites, edema, and amenia. The progress of the disease from this time on is rapid and fatal.

In making the diagnosis perhaps the most important single factor is that the examiner keep this disease in mind when studying an obscure case. Where the typical picture of large cervical glands is present, the diagnosis is easy in most cases: when the presenting symptoms are abdominal or thoracic, the diagnosis may be most difficult. The roentgen findings in these cases, although not characteristic, are of the greatest importance in establishing a correct diagnosis. The final diagnosis is usually made by biopsy, and this procedure should never be neglected, whenever possible. The roentgen findings of diagnostic importance, in the various manifestations of this disease, follow.

CHEST

In the chest, when lymphoblastoma involves the mediastinum or lung field, a variation from the normal can usually be demonstrated. The difficulty is in differentiating the findings from other causes.

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

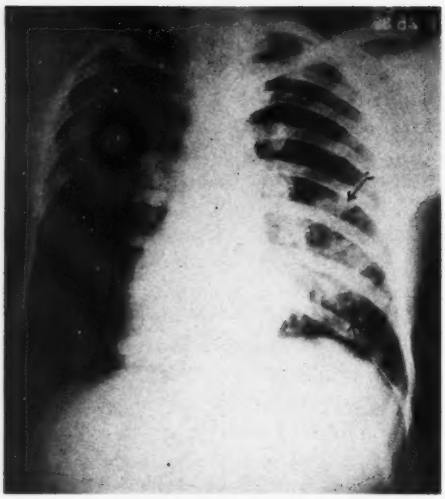

Fig. 1. Pulmonary manifestation in a case of lymphoblastoma of the Hodgkin's type. The right lung field is distinctly smaller and less radiant than the left. The hilus glands are moderately enlarged, and on the right side there is a band of mottled dullness extending across the chest from the hilus to the axillary border. In the lateral view, the process could be seen extending outward along the interlobar septum but there was actual infiltration of the lung tissue. The patient was a young man of 23 years. The presenting findings were glands in the neck. The diagnosis was confirmed by biopsy. The pulmonary symptoms did not develop until the patient had been under observation and treatment for about three years.

Usually, the disease first involves the peritracheal glands, as pointed out by Wessler and Greene many years ago. As the disease progresses, the hilus and peribronchial glands become enlarged, and in the later stages there may be actual infiltration of lung tissue. In rare atypical cases, a miliary-like process may be seen throughout the lung due to general involvement of the lymphoid tissues. Frequently, there is extension to the pleura with accumulations of fluid within the pleural spaces. In those cases which have received irradiation over the chest, the picture becomes even more complicated. With the destruction of lymphoid tissue, fibrosis may appear and narrow bands of dense tissue are seen radiating outward from the hilus. If the lung itself was involved before irradiation was given, actual areas of fibrosis within the lung substance may be seen so that the picture very closely resembles that of tuberculosis. When it is remembered that these cases are not infrequently complicated by tuberculosis, the diagnosis becomes increasingly difficult.

The roentgen findings in typical cases should consist, in the early stages of the disease, of a widening of the supracardiac shadow, the borders of which are lobulated. This increase in the mid-shadow may occur on one side only, but it is usually present on both sides. The shadow is quite dense, with sharply defined margins. There is no limitation of respiratory motion or infiltration of the lung itself. Occasionally, a single large rounded mass may appear to one or the other side of the mid-shadow just above the hilus, somewhat resembling an aneurysm. The trachea may, or may not, be displaced or narrowed. Usually, there is no displacement of the heart or great vessels. In the later stages of the disease, there may be an enormous increase in the mid-shadow extending well down into the hilus region. However, the borders retain their lobulated appearance and there is usually an absence of displacement of the mediastinal contents, and of interference with the passage of air into the lungs; the position and respiratory movements of the diaphragm are normal.

The lesions are differentiated from glandular tuberculosis by their size and extent, and by the absence of calcification within the masses. From carcinoma, the differentiation is based largely on the lobulated appearance of the shadows, their size, and the absence of interference with the flow of air to and from the bronchi. Since most carcinomas are bronchial in origin, obstruction occurs early—this is not true in lymphoma. From aneurysm, the differentiation can usually be made by rotating the patient under fluoroscopic observation, or by taking films in the first and second oblique positions. It can usually be shown that the mass is not connected with the aortic shadow.

The final diagnosis is usually made from the histologic appearance of a gland re-

moved elsewhere, or upon the reaction of the tumor mass to irradiation. It is very unusual for a true lymphoblastoma, uncomplicated, to fail to respond favorably to irradiation. In those cases complicated by tuberculosis, the biopsy may be misleading, and the x-ray findings extremely difficult to interpret. The diagnosis usually rests upon the finding of tubercle bacilli in the sputum, the failure of the lesion to disappear under proper irradiation, and the persistence of temperature. Involvement of the pleura or extensive miliary-like lesions in the lung are usually seen in the advanced stages of the disease, and the diagnosis can be made on evidence found elsewhere. It is only essential that the roentgenologist know that these findings may be of lymphomatous origin, and that it is not necessary to explain the picture in some other way.

Fig. 2. A case of lymphoblastoma of the Hodgkin's type, showing gastrointestinal lesions. The film was taken with only a small amount of barium in the stomach—the characteristic gyroscopy rugæ are well shown. The findings were confirmed at autopsy. The enlarged rugæ are general throughout the stomach. At the point indicated by the arrow *A*, definite tumor mass is visible.

LYMPHOMA OF THE GASTRO-INTESTINAL TRACT

Abdominal symptoms have been the presenting complaint in about 25 per cent of the cases with lymphoblastoma appearing in our Clinic. The lesion may occur anywhere in the gastro-intestinal tract, but is most frequently seen in the stomach and small bowel. It is more often a multiple rather than a single lesion, and, since other malignant tumors in the gastro-intestinal tract are rarely multiple, this, in itself, is of some diagnostic value. The disease frequently involves the abdominal glands, but it is when some part of the gastro-intestinal mucosa is involved that the characteristic picture is seen.

A study of the literature and the material in our Clinic has recently been made by Martin in an attempt to establish criteria which would make possible a roentgen diagnosis in this disease. The involvement of the gastro-intestinal tract does not appear to depend at all upon the type of lymphoma present. In the early literature, most of the cases reported were of the infiltrating type, and it was not until 1913, that the first cases of gastro-intestinal involvement of the Hodgkin's type were reported. This probably accounts for the general feeling among clinicians that Hodgkin's disease rarely, if ever, involves the gastro-intestinal tract. As a matter of fact, there are more reported cases of this type than any other. The gross pathologic appearance of the lesion varies widely, but they are usually multiple. A fact of considerable importance is the differentiation from other gastro-intestinal tumors. The location of the lesions within the gastro-intestine is also variable, but a common site is in the region of the pylorus or ileocecal valve. When the stomach is involved, there is often an accompanying lesion in the duodenum or upper portion of the small bowel. With involvement of the cecum, there is frequently an involvement of the terminal ileum. Occasionally, the

disease may appear as a single lesion in the stomach, cecum, or ileum, and permanent cures have been obtained by the surgical removal of such lesions. The gross appearance is that of an infiltrating tumor rarely accompanied by ulcerations; they may project into the lumen of the involved viscus, or they may produce a generalized contraction of the organ. Frequently, there is marked change in the mucosa of the organ involved. This change is more marked than in other tumors, and is particularly well shown in the stomach where the typical gyroscopic rugæ are seen. In these cases, the folds of gastric mucosa resemble somewhat the convolutions of the brain.

The roentgen findings in lymphoblastoma of the gastro-intestinal tract are not characteristic, and the lesion is frequently mistaken for carcinoma which it closely resembles. The finding of greatest importance, which should lead the examiner to suspect lymphoblastoma is a multiple lesion, particularly one involving both the stomach and duodenum. The lesion in the stomach resembles carcinoma; that in the duodenum ulcer with changes in the gastric or intestinal mucosa.

In our experience, the typical gyroscopic rugæ have been present in a high percentage of cases and have been found only once where lymphoblastoma was not present. Lymphoblastoma is usually accompanied by an enlargement of the spleen which can often be demonstrated during the examination of the gastro-intestinal tract by the roentgen ray; the fundus of the stomach may be displaced downward and to the right, and the space between it and the diaphragm increased. Lymphomatous infiltration of the stomach is less likely to interfere with the passage of the peristaltic wave or with the emptying time of the stomach than other similar lesions. In the typical cases with multiple lesions, gyroscopic rugæ, and enlargement of the spleen, the diagnosis can be made with considerable certainty from the roentgen examination alone. In less typical cases, a search elsewhere in the body, with the removal of a specimen for microscopic section, is usually necessary to establish the diagnosis. In the treatment of these cases, it is our belief that irradiation, when possible, should be preceded by surgical removal of the tumor mass. The rapid breaking-down of such a tumor under irradiation may result in perforation and peritonitis. This is less likely to occur if the mass of the tumor has been removed. In all cases, the treatment should be given with the greatest care. If radiation treatment is planned in a given case, one can readily see that it is of the greatest importance to establish the diagnosis between carcinoma and lymphoblastoma; the carcinoma dose would be highly dangerous in these cases.

LYMPHOBLASTOMA OF THE BONE

Lymphoblastoma of the bone is an uncommon finding and probably always secondary to involvement elsewhere, although the lesion in the bone may be the presenting symptoms. The bone most frequently involved is the sternum. Dresser, in 1926, reported three cases from our Clinic, and up to that time we had not observed this lesion in any other bone. Since then, we have observed an occasional case, and have found lesions not only in the sternum but in the spine and long bones. In all cases, however, the disease has been confined to the cancellous portions of the bone, and is a purely destructive process without evidence of new bone formation, or of periosteal proliferation. They closely resemble metastatic carcinoma in bone, but are usually a single lesion; whereas carcinomatous metastases are usually multiple. Their response to small doses of irradiation is a sign of some diagnostic value.

Lymphoblastoma frequently involves the brain, cord, urinary tract, and may involve any organ of the body: we have not been able to demonstrate its presence in any system other than the three just described. It should be possible to demonstrate the lesion when it occurs in the pelvis

of the kidney, but up to the present time we have not been able to do so, and it is doubtful if it has any characteristic appearance. The same is probably true with involvement of the spinal cord.

CONCLUSIONS

In conclusion, I would again call attention to the importance of keeping the possibility of lymphoblastoma in mind in all obscure cases, and the value to the roentgenologist of considering it as a generalized disease which may involve almost any organ of the body. It is particularly important that the roentgenologist be familiar with the appearance of this lesion in the gastro-intestinal tract, since a lack of this knowledge may result in serious mistakes. If a diagnosis of carcinoma is made, and the lesion is considered too far advanced for surgical treatment, either the benefit derived from irradiation may be neglected or an overdose of irradiation given, resulting in serious injury to the patient.

The knowledge that this process may attack almost any organ enables the roentgentherapeutist to correctly interpret unusual symptoms arising in the course of the disease and to apply adequate treatment.

A STANDARD IONIZATION CHAMBER FOR GRENZ RAYS

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ABSTRACT

A special type of chamber has been designed to measure the ionization produced by from 3 to 12 K.V. x-rays in a known volume of unrestricted air, thus making it possible to express the intensity of the x-ray beam in roentgens per minute. By the use of a very small guarded field ionization chamber (5 × 5 cm.), the air absorption correction is reduced several fold, and hence errors in its determination are not so serious in the final result sought. It is shown that air absorption corrections must be determined separately for each beam of radiation used, and the chamber is so designed that the necessary corrections may be determined without recourse to other special apparatus. Examples are given showing in detail the methods of making measurements with the chamber described. Compared at higher voltages (from 40 to 90 K.V.) with a large primary standard ionization chamber, the small type here described shows a divergence of about ±0.5 per cent which is believed to be the over-all error present in its use. In order to obtain this close agreement, it is necessary to take special precautions in the construction and measurement of the limiting diaphragm and the collector electrode.

I. INTRODUCTION

WITH the increasing clinical use of soft x-rays, excited by potentials of from 3 to 12 K.V. (peak), arises the necessity for their more accurate measurement such as is obtained with the higher voltage radiations. This is particularly important in view of the fact that such radiation may furnish an erythema dose in one or two minutes. In fact, errors in measurement assume even greater importance than for high voltage x-rays.

Although several investigators have reported on the measurement of soft x-rays (so-called Grenz rays), they have given but few essential details of the methods they employed.[1, 2, 3] This obscurity led us to construct an open-air ionization chamber capable of measuring soft x-rays, and to compare it with the standard used for measuring high voltage x-rays.[4] A chamber has, therefore, been designed which measures reliably x-rays excited by voltages ranging from 3 to 80 K.V. (peak), covering not only the "Grenz-ray therapy" (from 3 to 12 K.V.) but also the lower "diagnostic x-ray range" (from 60 to 80 K.V.).

Open-air chambers lacking a guarded field are not readily applicable to the measurement of soft x-rays because the large air absorption correction involved cannot be determined with desired accuracy. The principle of the guarded field air ionization chamber[4] renders it, however, particularly adaptable by permitting the air path between diaphragm and collector plates to be reduced to a minimum. The points essential to its successful application to low voltage x-rays are worked out in the present investigation.

II. DESCRIPTION OF CHAMBER

Described briefly, the guarded field ionization chamber furnishes adequate field uniformity, over the width of the collector electrode of a parallel plate ionization chamber, by means of properly

[1] H. Kustner, Strahlentherapie, 1928, **27,** 124.

[2] B. Rajewsky and G. Gabriel, Strahlentherapie, 1928, **30,** 20.

[3] Otto Glasser, Chap. III of Grenz-ray Therapy by Gustav Bucky (Macmillan, 1929). See also RADIOLOGY.

[4] L. S. Taylor and G. Singer, Bureau of Standards Jour. Research (RP 211), 1930, **5,** 507.

charged guard wires stretched across the open faces of chamber, the potentials of the wires being divided in equal successive scale S, which also serves as a "handle" with which to move the system from the outside.

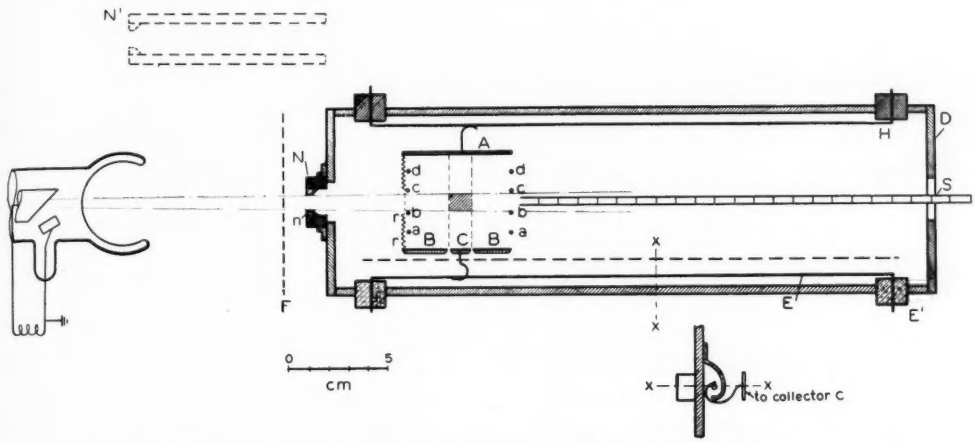

Fig. 1. Cross-section of special guarded field ionization chamber for measuring low voltage x-rays (3–80 K.V.).

steps between zero (at collector) and the plate potential. It has been shown that such a system permits the use of grounded metal parts (case, diaphragm, etc.) much closer to the electrodes than would otherwise be possible. In the present case, the shielding and the limiting diaphragm may be brought to within 5 cm. of the center of the collector plate, and air absorption correction need be made for this small distance.

A cross-section of this special ionization chamber for soft x-rays is shown in Figure 1. The electrode system consists of the high potential plate A, the two grounded guard plates B, and the collector electrode C, all mounted as a unit, similar to the larger type of guarded field chamber. The four rectangular guard wire loops, a, b, c, d, made of 10 mil aluminum, are maintained at equal potential steps, respectively, between earth and the potential of A by means of 5 half-megohm resistors, r, r, mounted on a hard rubber supporting frame. The entire electrode system can be slid the length of the box, D, on two guide rods, and its position read on the

The box D, is of $^1/_8$ in. brass, which provides sufficient radiation protection for lower voltage x-rays. For higher voltage x-rays, it is further shielded with about 1 mm. of lead. Potential to saturate the chamber is led on to the rod, H, upon which rests a sliding contact connected to A. Similarly the collector electrode, C, is connected by a sliding contact to E which leads to the electrometer system. The rod, E, is shielded over its entire length, as shown by the section X, for the purpose of preventing any ions not formed within the electrode system from reaching the electrometer system. The adequacy of this shielding was tested experimentally.

The diaphragm n, has an 8-mm. orifice with the limiting edges, cylindrical and about 1 mm. thick. The chamber as a whole is mounted on a base that slides in a direction parallel to the x-ray beam axis. A series of aluminum filters, F, about 3 cm. in diameter are mounted on a celluloid disc, the axis of which is independently movable parallel to the chamber's displacement.

III. OPERATION TESTS (CALIBRATIONS)

1. Collector Electrode.—Since the chamber is so small, it is imperative that its essential dimensions be known with high accuracy. The collector electrode being only about 1 cm. wide, along the length of the beam, an error of $^1/_{10}$ mm. in determining its effective width (true width plus one-half the width of both air gaps between collector and guard plate) would introduce an error of 1 per cent in the effective air volume. The necessity for determining this with accuracy is obvious. Accordingly, through the help of the gauge section of this Bureau, the following typical measurements were obtained:

Width of collector elect ode	9.492 ±0.005 mm.
Separation between guard plates	9.904 ±0.005 mm.
Effective collector width 9.6	98 ±0.005 mm.

Furthermore, to avoid field distortion at the edges, it is essential that the faces of the collector and guard plate lie exactly in the same plane. Field distortion at these edges presents one of the most serious obstacles to accurate current measurements in case, during the compensation of current, it is difficult to hold the collector at zero potential.

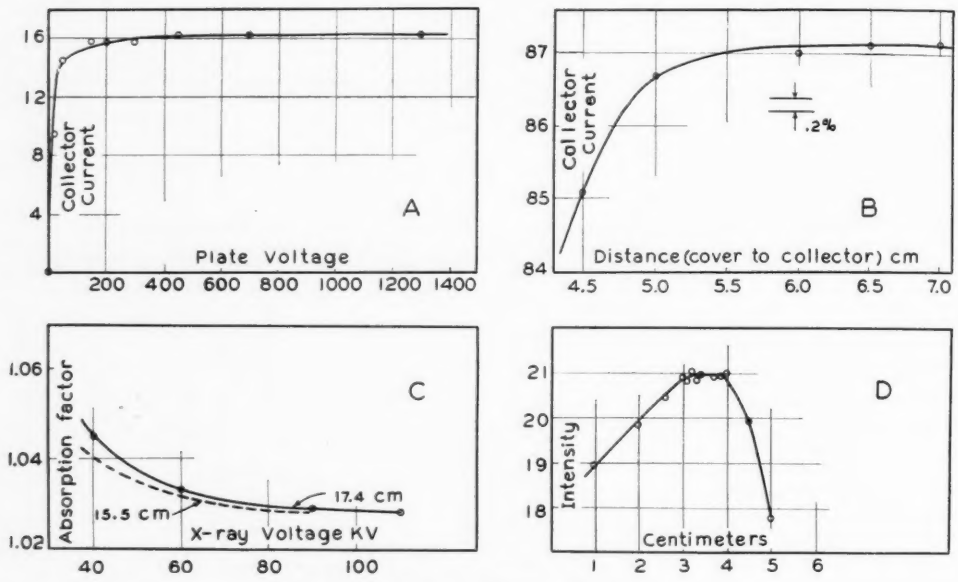

Fig. 2. Test curves of ionization chamber.

2. Chamber Limiting Diaphragm.—This diaphragm consists of a coin-gold sleeve, *n*, held in a Pb-Bi alloy ring, *N*. Its orifice was made and measured in two ways: the first by lapping the inner surface, and then measuring by the plug gauge method; the second by forcing a standard steel ball through an orifice which had been previously turned to a diameter of 1 or 2 thousandths of an inch less than the ball diameter. The latter method burnished the surface and at the same time determined its size. The measured diameters of two such diaphragms were:

Diaphragm 1 (plug gauge method)
7.8608 ± 0.0001 mm. at 68° F.
Diaphragm 2 (steel ball method)
7.9375 ± 0.0001 mm. at 6 ° F.

It is seen that the accuracy in determining the diameter by either method is about 1 part in 9,000.

3. Saturation Voltage.—Voltage to saturate the ionization chamber was supplied from a 1,300 volt D.C. generator. Curve *A* in Figure 2 shows that saturation was reached at about 300 volts; hence, for normal operation, 500 volts was applied.

4. Effect of Scattered Radiation.—In chambers for higher voltage x-rays, the limiting diaphragm must be placed at least from 10 to 15 cm. from the collector to avoid the influence of x-rays and γ-rays scattered from the diaphragm edges. Since the radiation from low voltage x-ray tubes must, in general, be measured so close to their source that a comparatively divergent beam enters the chamber, the customary type of chamber diaphragm is not satisfactory.

The diaphragm placed as shown by *N* in Figure 1 is satisfactory, provided the scattering from its walls is negligible. This was tested by measuring the ionization with the diaphragm in place, then again, after shifting it to the end of a 10-cm. extension tube, *N'*, the chamber being shifted so as to maintain the distance from *N* or *N'* to the tube target the same. Correction was made as shown later for absorption in the 10-cm. additional air path. Measurements at 40 K.V. (eff.) gave the following results:

Intensity, diaphragm at normal position	0.964 ±0.0033
Intensity, diaphragm shifted to 10 cm.	0.970 ±0.0027
Difference	0.006

The observed difference being of the same magnitude as the error of observation but in the direction opposite to that to be expected,[5] it is assumed that the two arrangements give identical results for the comparatively narrow beams used. In other words, the scattering effect from the walls of the diaphragm orifice is negligible.

Use of the divergent beam exposes the guard wires to the direct radiation and this may have a scattering effect. To test for scattering from this source, two strands of 20-mil aluminum wire were suspended, insulated, in the beam between the 10-mil guard wires *b* and *c*, hence did not influence the field. The following measurements were obtained at 40 K.V. (peak), with no filtration:

Intensity, wires in beam	0.295 ± 0.0016
Intensity, wires out of beam	0.294 ± 0.0008
Difference	0.001

The difference being of the magnitude of the experimental error, no appreciable effect arises from permitting the beam to strike the guard wires.

5. Field Distortion.—To determine how close the electrode system may be brought to the front end of the box without introducing appreciable field distortion, x-ray intensities were measured at each of several successive positions of the electrodes with respect to the box front. Curve *B*, Figure 2, shows the observed increase in ionization as the distance from collector electrode to the diaphragm is increased. Beyond 5 cm., further change is only about 0.2 to 0.3 per cent, a magnitude smaller than the experimental error in these particular measurements.

IV. COMPARISON WITH STANDARD CHAMBER

The reliability of the special ionization chamber was finally proved by comparing it with the primary standard on the higher voltage radiation. Since it was not feasible to do this directly, the special chamber was compared with a guarded field secondary chamber and this, in turn, with the guarded field primary standard. For the same beam of 70 K.V. unfiltered radiation, the following measurements show an agreement between the primary and secondary chambers closer than the experimental error:

(1) Primary standard ionization current	0.1315 ± 0.00026
(2) Secondary standard ionization current	0.1316 ± 0.00030
Difference	0.0001

Comparison of the special chamber with the secondary standard was made with

[5] This is probably due to error in the air absorption correction.

unfiltered radiation excited by from 40 to 90 K.V. (peak). To eliminate as many variables as possible, the same diaphragm was used interchangeably on both chambers. Likewise, the collector electrode of each chamber was connected to the same electrometer. Saturation voltages were supplied separately. Both chambers were placed in a fixed position and the tube shifted on a track, so that the same beam could enter either chamber as desired. To have this beam moderately well defined, a diaphragm 16 mm. in diameter was placed about 2 cm. from the wall of the 200 K.V. thin-walled Coolidge tube used.[6]

Ionization currents were measured by means of a null electrostatic compensator, such as was used in previous work,[7] wherein the ionization charge was compensated over a known interval of time. However, instead of exposing the chamber for a given time by means of an electrically operated shutter in the x-ray beam, the electrometer was connected to the chamber for a definite period by means of an electrically operated switch[8] located at E' (Fig. 1). The chamber and electrometer were connected by a shielded rubber cable.

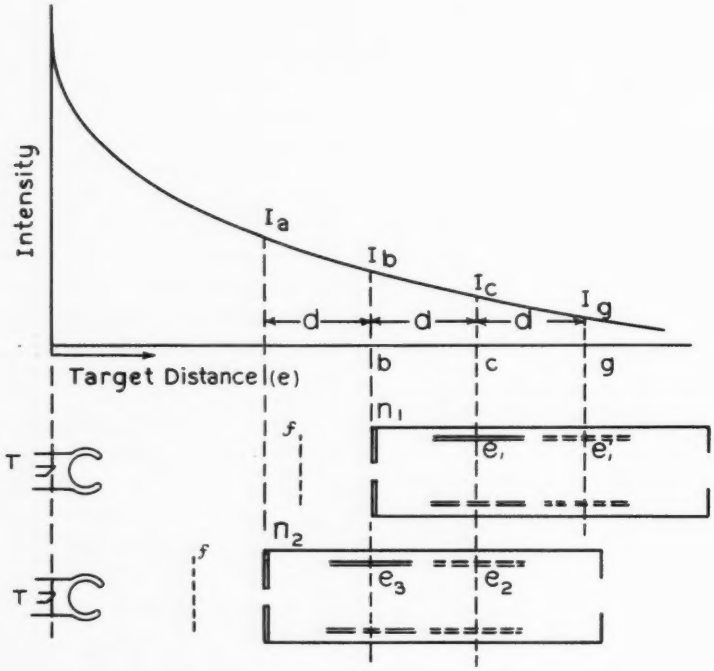

Fig. 3. Working positions of ionization chamber.

The effective length along the beam of the collector of the secondary standard was 4.975 cm. so that, for the same diaphragms, the effective air volumes ionized in the special and secondary chambers were in

[6] L. S. Taylor, Bureau of Standards Jour. Research (RP 56), 1929, **2**, 771.

[7] L. S. Taylor, Bureau of Standards Jour. Research (RP 306), 1931, **6**, 807.

[8] L. S. Taylor, Bureau of Standards Jour. Research (RP 397), 1932, **8**, 9.

the ratio 0.9698 to 4.975. All readings with the secondary chamber were, therefore, divided by 5.129 to reduce to the same effective air volume as the special chamber.

The distance between the limiting diaphragm and center of the collector electrode on the secondary chamber was 22.5 cm., as compared with 7 cm. for the corresponding distance on the special chamber. Absorption in the air path difference of 15.5 cm. will, for the same beam, lower the measured current of the secondary chamber relative to that of the special chamber by a corresponding amount. Since this absorption depends upon such factors as voltage wave form, tube characteristic, and tube wall thickness, it must be determined for each set of conditions employed.

At voltages ranging from 40 to 100 K.V. in which the x-rays pass initially through moderately thick tube walls, the radiation is sufficiently hardened so that its quality undergoes no appreciable further change in passing through 50 cm. of air. In such case the air absorption is approximately proportional to the length of the air path.[9] But, as shown later, this is not true for the 4 to 12 K.V. radiation for which the special chamber is designed.

Air absorption measurements to be applied in the present comparison were made with the large open-air standard ionization chamber,[10] using the limiting diaphragm in a fixed position relative to the target so as to define a narrow beam passing between the chamber plates. X-ray intensities, I_1 and I_2, were then measured with the plates at the distances 110.6 and 128.0 cm., respectively, from the target. The ratio $\frac{I_1}{I_2}$, giving the air absorption correction factor for an air path of 17.4 cm., is plotted against applied voltage in Curve C of Figure 2. The absorption being practically linear with distance, it is simple to correct it to fit any path length as, for example, 15.5 cm., required in the present set-up and shown by the broken curve.

To insure, in the comparison, proper alignment of the special chamber, measurements were made of the intensity of the x-ray beam over its horizontal cross-section in the plane of the diaphragm, N. As shown by Curve D in Figure 3, the area of effective uniformity, about 1 cm. wide, indicates the range of proper alignment.[11]

Typical results of the comparison of the special with the secondary chambers, with unfiltered radiation from a thin wall, deep therapy Coolidge tube, are given in Table I.

TABLE I.—COMPARISONS OF SPECIAL IONIZATION CHAMBER WITH SECONDARY CHAMBER

K.V.	I_g	I_x	Absorption factor $(I_1/I_2)_{15.5}$	$\frac{I_g}{I_x}\left(\frac{I_2}{I_1}\right)_{15.5}$
40	4.63	4.46	1.040	0.998
50	2.30	2.205	1.033	1.008
70	2.88	2.79	1.028	1.003
90	6.08	6.08	1.027	0.968

Column 2 gives the intensities I_g in roentgens per minute as measured with the special chamber; Column 3, the intensities, I_x at the middle of the collector, as determined with the secondary standard but uncorrected for air absorption in the extra 15.5 cm. of path; Column 4, the corresponding air absorption factor, as obtained from the broken curve of Figure 3C and by which I_x is multiplied in order to obtain the intensity 15.5 cm. nearer the diaphragm, at which point the special chamber is used; and the last column gives the ratio of the intensities furnished by the two chambers.

At 90 K.V. (peak) the small chamber indicates definitely too little ionization. This is attributed to the close spacing (5 cm.) of the collector, C, and high potential plate, A, which does not permit full utilization of the range of the photoelectrons

[9] L. S. Taylor and G. Singer, Bureau of Standards Jour. Research (RP 271), 1931, **6**, 219.

[10] L. S. Taylor, Bureau of Standards Jour. Research (RP 56), 1929, **2**, 771.

[11] L. S. Taylor, Bureau of Standards Jour. Research (RP 119), 1929, **3**, 807.

emitted along the path of the x-ray beam. This sets a definite x-ray voltage limit above which the small chamber should not be used. The safe working range for the present chamber includes, however, the lower part of the diagnostic x-ray region and may be used where, due to "wall effect," measurements with most thimble ionization chambers become inaccurate.

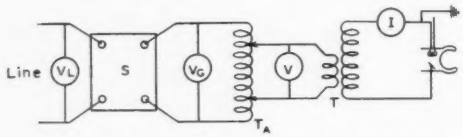

Fig. 4. Diagram of power input to Grenz-ray tube.

V. MEASUREMENTS OF GRENZ RAYS

Having found agreement between the indications of the special and the standard chambers at voltages ranging from 40 to 80 K.V. (peak), the use of the special chamber may be extended down to any x-ray voltage for which adequate air absorption correction can be made.

For measuring so-called "Grenz rays," 4 to 12 K.V. (peak), the necessary corrections will be indicated and the necessity for accurately measuring the air absorption for each set of experimental conditions under which the radiation is used will be brought out.

Very soft x-rays (4 to 12 K.V.) are absorbed by air to such a degree that the radiation quality changes rapidly even in a distance of only 5 centimeters. The beam intensity should, therefore, be measured at the exact position, with respect to both tube and filter, where the radiation is to be applied, because it is unsafe to apply the inverse square law for computing intensities at points other than where measured. Furthermore, it is essential to determine the air absorption between diaphragm and collector, C, for an air column having exactly the same position with respect to the target as the column between diaphragm and collector when the chamber is in its working position, if the point of application is taken at the position of the limiting diaphragm.

The requirements are illustrated in Figure 3 which gives a plot of the intensity of an x-ray beam as a function of the distance, e, from the target, T. At the lower part are indicated several possible positions of an ionization chamber with respect to the tube. Suppose, for example, the intensity, I_b, at the position, b, is to be measured. The chamber diaphragm would be placed at position, $n_1 \equiv b$, and the middle of the collector electrode at e_1, a distance, d, from n_1, where d is the minimum working distance between collector and diaphragm. Owing to air absorption over the path, b–c, the intensity measured at e_1 must be corrected to give the value as if at the position, n_1. This correction cannot be obtained by simply keeping n_1 fixed, and moving e_1 away an equal distance, d, to the position e_1' because, due to the filtering action of the air, the radiation quality at g is different from that at c.

To obtain the air absorption factor to be applied in the chamber working position, it is necessary to move the chamber, including diaphragm, toward the tube a distance, d, to the position, n_2, and then measure the intensities, I_b and I_c, obtained respectively at the two positions of the collector plate, $e_3 \equiv n_1$, and $e_2 \equiv e_1$. The ratio $\frac{I_b}{I_c}$ gives the air absorption factor to be applied to the readings made with the chamber at the position n_1. Corrections made in this manner are limited to distances, d, or greater, from the x-ray tube. The special chamber described, owing to its small size, is particularly well adapted to the problem; an unguarded field type cannot be made sufficiently small without introducing too great field distortion.

The observed change in the air absorption factor, as the distance from the tube is changed, is given in Table II.

TABLE II.—AIR ABSORPTION FACTORS
8 K.V. (PEAK)

(Slack window, Grenz-ray tube)[12]

Diaphragm position	Absorption path distance from target	Absorption factor
1. (a–b)	12–18 cm.	1.635
2. (b–c)	18–24 cm.	1.593
3. (c–d)	24–30 cm.	1.576

The letters in parenthesis refer to the positions in Figure 4. The correction factor changes between Positions 1 and 2 by 4.2 per cent; between 2 and 3, due to hardening of the radiation, by only 1.7 per cent. This proves that air absorption corrections made in one position cannot be applied to another position without introducing a corresponding error.

It is also evident from these measurements that, as the distance, d (Fig. 3), of the middle of the collector electrode increases, the absorption correction correspondingly increases and may become so large that its accuracy of determination is insufficient. It is obvious that d should be kept as small as possible. With the chamber used here, d may be as small as 5 cm. for radiation up to 80 K.V. (peak); while, for the same range, a simple parallel plate or cylindrical ionization chamber would have a minimum distance d = 13 cm. and, therefore, at least double the absorption correction.

Measurements were made using a commercial Grenz-ray generator and a tube with a thin indrawn-bubble type of window[13] of such size and position that the ionization chamber diaphragm could be brought to about 5 cm. of the target. The filament side of the tube was grounded (Fig. 4), and the voltage regulated by means of a slide wire autotransformer T_A in the primary circuit of the high voltage transformer. Peak voltage was determined from the manufacturer's calibration in terms of the voltage, V, on the primary of the transformer. (Since accurate values of the tube voltage were of no great significance in this particular work, the voltage calibration was not checked.)

Air absorption, expressed in terms of an absorption factor, I_b/I_c (see Fig. 3), multiplied by the ionization reading, I_c, gives the intensity in roentgens per minute at the point, b, the position of the limiting diaphragm. The absorption factor, I_b/I_c, for d = 6 cm. is plotted in Figure 5 as a function of the thickness of aluminum filter used in the beam. It is seen that for lightly filtered radiations, air absorption correction may be, with 6 K.V. radiation, as large as 40 per cent. The need for accuracy of this correction is obvious.

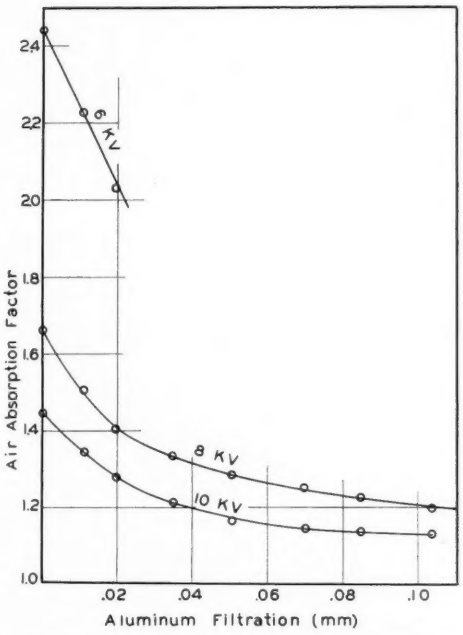

Fig. 5. Air absorption factor for Grenz rays.

Figure 6 gives a series of curves showing the intensity, Ib, in roentgens per minute at the position b = 12 cm. as a function of the aluminum filtration. The lower curve of each pair gives the measured intensity while the upper curve gives the corresponding calculated value at the

[12] C. M. Slack, Jour. Opt. Soc. Am., 1929, **18**, 123.
[13] See Footnote 12.

diaphragm—obtained by multiplying by the appropriate absorption factor from Figure 6. It is interesting to note in this connection that a lateral shift, corresponding to 0.0055 mm. thickness of aluminum, of the first curve of any pair brings the two

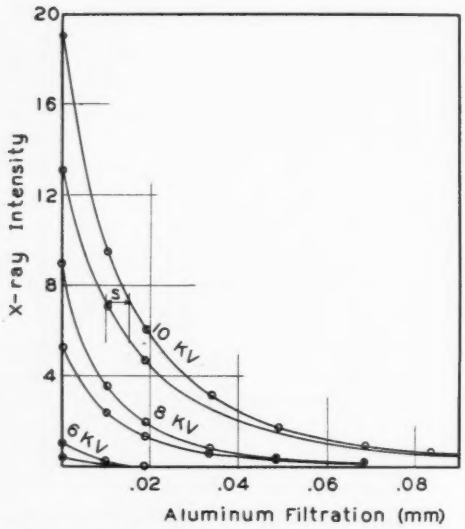

Fig. 6. Ionization intensity curves for Grenz rays.

curves together, within experimental error. This means that the absorption of 6 cm. of air is equivalent to 0.00055 cm. of aluminum for the range of voltages and qualities covered in Figures 5 and 6. The aluminum equivalence of air is from this 9.2×10^{-5} mm. Al per mm. of air, which agrees favorably with the value 9×10^{-5} reported by Siegbahm[14] but is appreciably higher than Glasser's value of 7.9×10^{-5} millimeters.

[14] M. Siegbahm, The Spectroscopy of X-ray (Oxford), 1925.

The logarithm of the intensity plotted against thickness of filter shows a distinct curvature up to 0.1 mm. Al filtration and indicates that there is no "homogeneity filter"[15] beyond which the quality does not change. Typical examples of intensity and absorption curves for Grenz rays have been given by Jacobson[16] and others. Such curves have value only for a particular tube and should be determined separately for each type of generator, as brought out by using the system indicated in Figure 4. Here tube emission was measured for a constant voltage, V, applied to the transformer, T, and constant current, I, through the tube, the input voltage, V_G, to the control autotransformer being stabilized in one case and unstabilized in the other.[17] The results in Table III show a

TABLE III.—GRENZ-RAY EMISSIONS FOR DIFFERENT VOLTAGE WAVE FORMS

Line voltage V_L	Stabilizer	Input voltage V_G	Emission
109	out	109	16.07
104	out	104	16.24
109	in	106.5	8.83
104	in	106.5	8.52

50 per cent decrease in emission with the particular type of stabilization used. Since the effect of wave form on emission varies between tubes of different types, there is little to be gained by further investigation of the variation; it simply emphasizes the necessity for individual measurements with each type of generator used.

[15] H. Behnken, Zeit. fur. Tech. Phys., 1921, **2**, 153.

[16] L. Jacobson, Am. Jour. Roentgenol. and Rad. Ther., 1929, **22**, 547.

[17] All stabilizers of the general type here used, produce a distorted wave form in the output, depending upon the load power factor. This does not in any way effect their usefulness for their intended purpose.

CHOLECYSTOGRAPHY WITH TETRAIODOPHENOLPHTHALEIN BY MOUTH; EXPERIENCE WITH REGARD TO SUCCESS AND UNTOWARD REACTIONS[1]

By R. R. NEWELL, M.D., *and* EDWARD LEEF, M.D., *San Francisco*

From the Department of Radiology, Stanford University School of Medicine

IN the past five years we have given to 1,257 patients tetraiodophenolphthalein by mouth. In 1,000 of these (80 per cent), the tetraiodophenolphthalein collected in the gall bladder to a visible degree. By chance they were studied in two nearly equal groups: Of 695 cases studied in the first 3 years, 84 per cent visualized; of 562 cases studied in the last 2 years, 74 per cent visualized.

The observed difference between these two samples of cases is more than ten times their standard error. If our technic has not decreased in efficiency, we may suppose that our patients have in later years been more narrowly selected.

TECHNIC

We think that neither catharsis nor enema is a desirable routine in preparing a patient for gall bladder examination. First, two films of the gall bladder region are made, searching for calcified stones. The radiologist sees these films in case any suggestive shadow needs further study, as, for instance, a lateral view. Then (or after the six-hour examination, as in the usual case when the patient is also having a gastro-intestinal study) he is given the following typewritten instructions:

At four o'clock (4:00 P. M.) drink glass of half milk, half cream. Supper at 8:30, consisting of tea with sugar but no milk or cream; two slices of toast with jam or jelly but without butter; stewed fruit and fresh fruit; baked potato without any cream or butter. Immediately after supper, thoroughly mix the entire bottleful of tetradol into a glassful of grapejuice and drink all of it. If any remains in the bottom of the glass, use more grapejuice to dissolve it. Nothing but water can be had until midnight, and thereafter nothing at all by mouth. Come to the x-ray department at eight o'clock to-morrow morning, without breakfast.

At 8 A.M., a single film is made of the gall-bladder region, at 60 K.V., using the Bucky diaphragm. The radiologist looks at the film and if he is dissatisfied with the visualization on this 11-hour film, another is taken (still fasting) at fourteen hours. If still no satisfactory shadow is visible, we usually have the patient repeat the 4-gram dose that evening and return for another 11-hour film and, if necessary, a 14-hour film the next day. As soon as a satisfactory shadow is seen (if ever) the patient is told to eat breakfast (fatty) and return two hours later for a last film.

We wish to lay stress on the desirability of having the radiologist see each gall-bladder film as soon as developed so that any necessary films (lateral or in opposite respiratory phase) may be taken to clear up doubt or suspicion.

For five years we have used the same preparation, namely, tetradol emulsion (National Aniline and Chemical Company)[2] 4 grams, always drunk in a glassful of Welch's grapejuice.

The intravenous method was originally our routine. Before changing to the oral method as a routine, we gave 31 patients 3 grams of tetraiodophenolphthalein in colloidal suspension (precipitated by CO_2 gas), and then at a later date gave the same patients 2 grams of the same drug in solution intravenously. In two cases, concentration after oral was greater than after intravenous administration; in four cases concentration was the same. In 18 cases, concentration after intravenous was greater

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

[2] Our results do not give information as to which of the commercial preparations of tetraiodophenolphthalein available gives the best results or shows the fewest reactions. Our continued use of the one preparation has been solely in the interests of uniformity.

TIME RELATION OF SUPPER TO TETRAIODO

EFFECT ON INCIDENCE OF REACTIONS AND ON SUCCESS OF VISUALIZATION.

		REACTIONS PER CENT							SUCCESS PER CENT. OF CASES ATTAINING OR SURPASSING A GIVEN PERCENTAGE CONCENTRATION IN THE GALLBLADDER					DID NOT VISUALIZE
		NAUSEA	VOMITING	DIARRHEA	HEADACHE	CHILLS	CRAMPS	NO REACTION	2 ½	2	1 ½	1	½	
EARLY MEAL	93 CASES	28	5	45	14	5	16	35	—	24	29	64	76	24
LATE MEAL	469 CASES	60	10	44	14	10	22	34	7	35	41	60	73	27

Table I.

178 CASES IN WHICH FILM WAS MADE 14 HOURS AS WELL AS 11 HOURS AFTER ORAL TETRAIODO.

OBSERVATION AT 11 HOURS		OBSERVATION AT 14 HOURS	
NO SHADOW	102 CASES	½% CONCENTRATION, OR BETTER	17 CASES
		STILL NO SHADOW	85 CASES
½% TO 1% CONCENTRATION	76 CASES	CONCENTRATION IMPROVED	24 CASES
		CONCENTRATION NO BETTER	52 CASES

Table II.

RESULTS OF IMMEDIATE REPETITION OF TESTS

OBSERVATION AT 11 & 14 HOURS 1 ST. DAY		OBSERVATION	2 ND. DAY
NO SHADOW	27 CASES	2% CONCENTRATION	10 CASES
		1% "	2 CASES
		½% "	1 CASE
		NO SHADOW (at 11 or 14 hours)	14 CASES

Table III.

than after oral administration, including three instances in which visualization was obtained only by the intravenous method. There were seven cases that gave no visible shadow at all.

Later, we tried several preparations for oral administration, volunteers taking four kinds at different times. Although this did show us that commercial preparations are better than our CO_2 precipitated dye, yet we believed the intravenous method more dependable. However, the difference was not thought sufficient to outweigh the advantages of a simpler technic and the avoidance of an occasional thrombophlebitis.

REACTIONS

We are reporting here our study of reactions after tetraiodophenolphthalein by mouth. We have not carried out our original intention of studying a similar series intravenously. We hope that some who are doing this routinely will give us their experiences to compare with our own.

Davis (1) reported a series of 305 cases showing the incidence of reactions following the intravenous method. His findings confirm our impression, namely, that reactions are definitely less by the intravenous method. Only 75 of his 305 cases suffered reactions.

Under the term of "reactions" we have grouped all those unpleasant symptoms that not infrequently follow oral administration of tetraiodophenolphthalein (Chart I). We have recorded these carefully since February, 1931, and present a tabulation only for these later cases. Our data for reactions after intravenous tetraiodophenolphthalein are too few to be statistically significant.

Besides the unpleasantness of these reactions, we have to consider their interference with the success of the test. Chills and vomiting (fortunately not frequent) seem definitely to lessen the chance of success. However, we have seen (2) several cases in which vomiting came within 20 minutes of ingestion, yet was followed by good concentration in the gall bladder. Intestinal symptoms (cramps and diarrhea) do not seem to prevent the absorption of the dye. Our data give us a basis for deciding how worth while are certain details of technic.

Time of the Evening Meal.—The tetradol emulsion has always been given about 9 P.M. We have 93 cases in which the low fat supper was taken about three hours prior to the dye, and 469 cases in which supper was put off until about 8:30 P.M. On the whole, reactions were more frequent in the latter series. The late supper yielded a few more non-visualizations, but tended to a higher degree of concentration in those that did visualize.

If the first film shows no shadow, a second film 3 hours later is of definite value. We found one chance in six that the second film would show a gall-bladder shadow. A second dose of dye given 24 hours after the first dose (which had failed to give a visible gall-bladder shadow) succeeded in bringing up a satisfactory shadow in half of the cases tried. The sight of food does not in our experience cause the gall bladder to empty. We are reporting this separately (3).

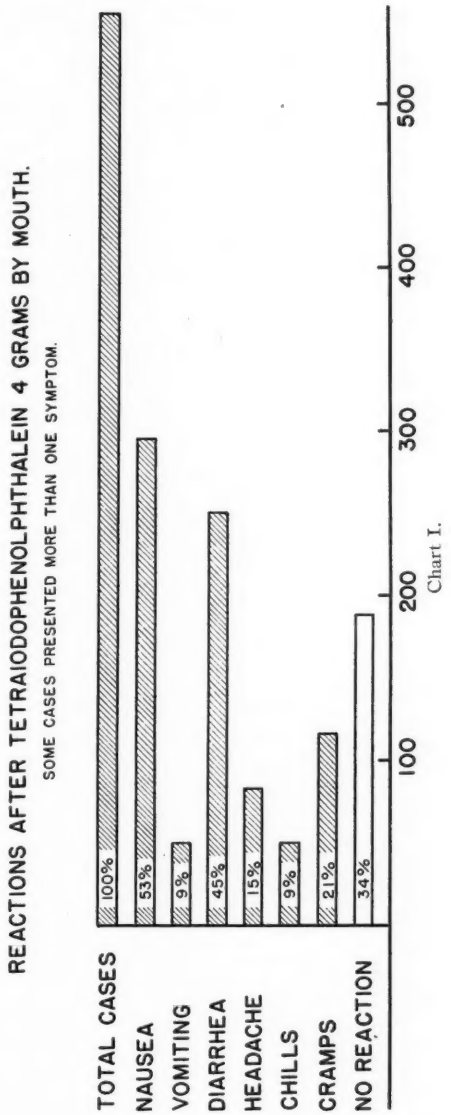

Chart I.

CONCLUSION

A review of our experience in gall-bladder visualization with tetraiodophenolphthalein by mouth convinces us:

(1) That as a routine test it is fairly satisfactory (80 per cent visualizations).

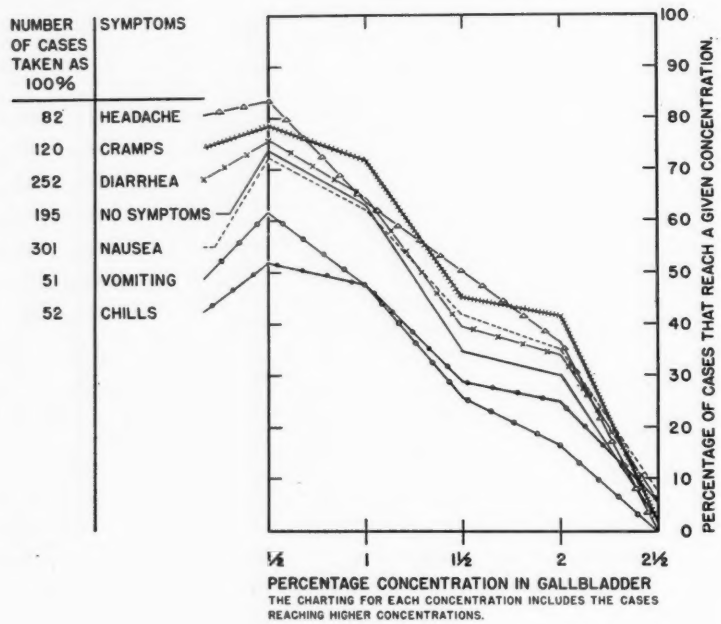

Chart 2.

(2) That reactions are frequent and may be distressing: we have seen none that seemed dangerous.

(3) Reactions have comparatively little influence on the success of the test.

(4) A single careful film is sufficient, however, if on the failure to obtain a satisfactory shadow, a second film is taken three hours later.

(5) Such a second film will succeed in one-sixth of the cases tried.

(6) Failure to get a good shadow should lead one to repeat the dose at twenty-four-hour intervals. This succeeded in half the cases tried.

(7) Sight and smell of food have no influence on the emptying of the gall bladder.

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PHYSIOLOGY OF THE GALL BLADDER: CHOLECYSTOGRAPHY SHOWS NO PSYCHIC EMPTYING[1]

By EDWARD LEEF, M.D., *San Francisco*

From the Department of Medicine, Stanford University School of Medicine

IT has long been known that chyme, especially fatty chyme, on entering the duodenum causes the gall bladder to empty. Ivy and Oldberg (1), in 1928, showed that the mechanism for this stimulation is *via* the blood stream and named the mediator cholecystokinin. Boyden (2), in 1928, showed in several instances that there was a slight response to the smell of food, but that the amount of bladder bile released was negligible. Sandblom (3), in 1933, observed gall-bladder contraction after human subjects had received blood transfusion from donors recently fed egg yolks. Puestow (4), in 1931, showed in dogs a slight flow of bile at the smell of food. We wished to know if "psychic stimulation" might be affecting our routine tetraiodophenolphthalein tests in man.

We did this in the following manner. If we found two patients the same morning whose gall bladders were filled with a good concentration (2%) of tetraiodo, these two were sent together to the diet kitchen where one would watch the other eat an appetizing breakfast consisting, among other foods, of bacon and eggs, but would himself eat or drink nothing. Both would then return for another film. The fasting one would then go to his breakfast and return for a third film. We tried six such pairs. In all cases the gall bladder failed to empty in any perceptible degree at the sight and smell of food, but did subsequently empty after actually eating the food.

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

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ROENTGEN-RAY BURNS

WITH REPORT OF NINE CASES FROM UNIVERSITY HOSPITAL, PHILADELPHIA, 1907 TO 1933

By GEORGE S. ZUGSMITH, M.D., *Pittsburgh, Pa.*

THE story of the dangers and untoward results of x-ray radiation and radium emanations is one of the bravest yet saddest tales of modern medicine. It has been a long time since 1896 when Marcuse (1) reported a case of dermatitis attending the use of roentgen rays, and a malignancy on an old x-ray dermatitis. The knowledge of prevention of burns has advanced greatly since then, but it was only recently, 1928 in fact, that Posey (2) reported two cases of deep burns of the throat resulting from x-ray treatments, lasting from 10 to 15 minutes, which were administered by the physician, or his son, and when neither of them could give the treatment, by the colored maid. As to etiology, Lossen (3) recognizes three different kinds of burns: primary burns, as a result of technical errors; secondary burns, as a result of cumulative effects (endogenous causes), and those resulting from a combination of outer circumstances. Porter (4) groups his cases more specifically: lesions resulting from a single massive dose, intentional or otherwise, or a few exposures at short intervals; cases with chronic diseases (pulmonary tuberculosis, lupus, psoriasis, eczema) and treatment of malignant disease with many exposures over a long period; professional roentgenologists, many of them physicians, who used roentgen rays before knowing their dangers and the proper precautions, or without exercising the latter.

ETIOLOGY

It has been generally agreed that there is no idiosyncrasy to roentgen rays. Del-Buono (5) said: "The pathological phenomenon of idiosyncrasy occurs for minimal doses of the drug or element which brings it about, and its effect, in the organism in general, is manifested by a shock. Feeble doses of x-rays should then produce skin lesions which should result in severe burns, ulceration, and extensive necrosis." It must be acknowledged, however, that there is a definite variation in the susceptibility of the skin of a degree too small to be idiosyncratic. Bergonié (6) spoke of the state as one of indirect or physical anaphylaxis. Wintz (7) showed that healthy skin does not show variation of more than from 10 to 15 per cent in its reaction to x-ray, although damaged skin or general disease may increase the sensitivity. Persons already in a toxic condition are more prone to manifest acute constitutional symptoms than are healthy individuals. Davis (8) showed that syphilitics and cases with Bright's disease do not react favorably to the x-ray. Figi (9) stated that the type of person most susceptible to the x-ray was one with a fair and ruddy complexion, red hair, and a thin dry skin. Desjardins and Smith (10) thought that the degree of exposure required for irritation depended upon:

(1) The complexion of the individual, and his natural pigments;

(2) The part of the body (thickness of the skin and the number of cell layers);

(3) The metabolic state of the skin as affected by circulatory and nervous activity.

They believed that areas of increased heat and moisture such as are present in the axilla, groin, perineum, and fatty folds in the obese, were more sensitive. The use of certain chemicals on the skin, such as iodine, scarlet R, mercury, pyrogallic acid, cantharides, resorcin, beta-naphthol, tar, iodoform, sulphur, and salicylic acid, also raised sensitivity. Martin and Caldwell (11) found that other factors influencing the sensitivity were: menses, pregnancy, diabetes, arteriosclerosis, gout, ca-

chetic states, injuries, age of the patient, area of the body exposed, local anemia, dryness of the skin, acidity of the sweat, and cutaneous vasomotor irritability. DelBuono (5) reported a case in which a knee wrongly diagnosed as tuberculous was irradiated: a burn developed, and a histologic examination disclosed an old trichinosis.

Sampson (12) believed that the sensitivity was due to differences in skin temperature. He based his conclusions on the occurrence of burns in the folds of the axilla, etc., in the obese, and on the severe reactions obtained following the application of ice-bags to a part after irradiation. In some experiments on rabbits, with suitable controls, Martin and Caldwell (11) applied adhesive tape to an area shortly after irradiation and ulceration resulted. They ascribed this ulceration to the higher skin temperature under the tape—moisture as a factor was ruled out since rabbits do not perspire. Rabbits, following irradiation, similarly exposed to cold by means of ice-bags also had ulceration. Other writers showed that it was the amount of blood in the tissues that determined the sensitivity and, therefore, not the temperature *per se*, but the hyperemia produced by the temperature changes which caused the ulceration. DelBuono (5) showed that the less blood contained in the tissue, the less will be its sensitivity, and that an injection of adrenaline, causing capillary constriction, raised the ability of the area to withstand the ray.

GROSS PATHOLOGY

Highman and Rulison (31) thought that x-ray produced a series of events paralelling scleroderma. The types of pathology from the work of Desjardins and Smith (10) and Davis (8) lend them to a grouping as follows:

First Degree.—Depilation and tan pigmentation occurs within from 10 to 20 days following the exposure, and ends in desquamation. Repeated burns of this degree lead to chronic radiodermatitis in which there is a dryness of the skin with a tendency to cracking, atrophy telangiectases, permanent alopecias, and keratoses.

Second Degree.—Erythema appears in from 7 to 14 days, and there is exfoliation lasting from one to three weeks. Vesiculation occurs, and the epidermal covering of the vesicles separates. The erythema shades off to bronzing and leads to atrophy after from one to three years. If the doses are repeated, they may lead to subcutaneous edema and a dense, brawny induration.

Third Degree.—Practically all of these burns are the result of gross errors in the estimation or administration of the dosage. Evidences of extreme irritation may appear within two or three days and, after passing through short stages of erythema and vesiculation, proceed to the point of ulceration. The burned area is often tightly adherent to the underlying tissue and may be somewhat depressed. There are usually patches of keratoses and one or more chronic ulcers which may be superficial or may involve the full thickness of the skin and also a considerable portion of the soft parts. Some heal and then break down again, while others never heal without surgical intervention. The healed or unulcerated portions are hairless and atrophied, wrinkled or smooth, usually dry, shiny, and have a blotchy, brownish-blue pigmentation. The subcutaneous fat may be completely destroyed, the muscle may be infiltrated or entirely replaced by scar tissue, and there may be necrosis of the underlying bone. The ulceration is limited either wholly or on one or more of its sides by a relatively sharp outline corresponding to the area exposed. The edges of the ulcer are thickened, hard, grayish-red, and frequently everted. Its surface is covered by a grayish, necrotic layer, and sero-purulent exudate. The natural tendency to repair is held in abeyance and, in some cases, the involved area may remain intact for a long period without breaking down, but if traumatized, small ulcers develop and gradually extend to the margins of the field. According to Fouts (14),

disintegration and sloughing, once having begun, will continue until a point is reached where there is a sufficient blood supply to maintain life in the tissues. Even beyond this point there is much fibrosis and the tissues are badly crippled.

MICROPATHOLOGY

The action of radiation on cells appears to demonstrate to Mitman (15) that if the energy of radiation is sufficiently great all cells are destroyed, though not necessarily at once; if the radiation is less intense, only the more sensitive ones are destroyed (*Supra*, Michael *et al.*). If an important function is destroyed, the cell ages rapidly; if only inhibited, the life of the cell is shortened. Even if there is no apparent inhibition of function, there may still be some slight damage. In radiodermatitis, the ulcerated area is surrounded by a zone of inert but living cells which, having lost their ability to multiply, cannot participate in the process of repair, hence the intractability. DelBuono (5) believes that the capillaries of the corium are affected by very small dosage. The first consequence is the loss of elasticity, so that the vasomotor apparatus no longer functions well and the skin is handicapped in its power of resistance. For larger doses, the lumen of the capillaries becomes smaller, even to obliteration, or an extravasation may occur, with subsequent telangiectasis. Duerck, quoted by Matas (16), believed that the underlying pathology was a progressive, proliferative endarteritis, obliterating the arterioles of the derm and subdermal connective tissue, leading to a gradual but fatal ischemia and nutritional disturbance in the radiated field. Whether initiated primarily in the endothelium of the arterioles, or secondary to correlated changes in the perivascular connective tissue, is not fully determined, but the latency is explained by endothelial proliferation. Cole (17) found the specific changes to be: (1) smooth muscle swollen, due to vacuolation and distention of the cells with hyaline material; (2) blood vessels obliterated; (3) capillaries showing telangiectases; (4) in the hands, the bones show absorption of osseous tissue of the whole or part of the terminal phalanx. There is swelling of the collagen, in the corium, subcutaneous tissue, and walls of the blood vessels, as shown by Wolbach (18, 30). This altered connective tissue does not regenerate, but new connective tissue is laid down by surviving or ingrowing fibroblasts, and this is the process that leads to the shrunken, indurated condition of chronic x-ray dermatitis, and accounts for thickening of the blood vessels. Skin and experimental tissues show swelling of cells and mitotic division on about the fourth day, and in the superficial layers there is a polymorphonuclear reaction to actual necrosis. The human changes are: (1) complete loss of the appendages of the epidermis; (2) replacement of the normal collagen by a peculiarly dense hyaline collagen, rich in elastic fibers and poor in cells; (3) obliterative processes in the blood vessels of the corium and subcutaneous tissues; (4) necroses of varying size in the corium, immediately beneath the epidermis, in the earlier stages around thrombosed telangiectases (in the later stages these telangiectases may be nearly absent); (5) response to necroses by reparative proliferation of a part of the epidermis. The immediate, initial change is a focus of localized edema beneath the epidermis. The epidermis becomes separated from the viable corium by an edematous layer which contains only necrotic cells which is often infiltrated with fibrin. There is practically no attempt at repair by the organization of these minute subepithelial necroses owing to the pathologic condition of the deeper-lying connective tissues. The gap is speedily covered by the regeneration of the epidermis so that the effect of the occurrence of these necroses is to produce a downward migration of the epidermis. This epidermal proliferation is not supported by corium, since the corium is destroyed. This sustained proliferation, for many years in contact with an abnormal supporting tissue, Wol-

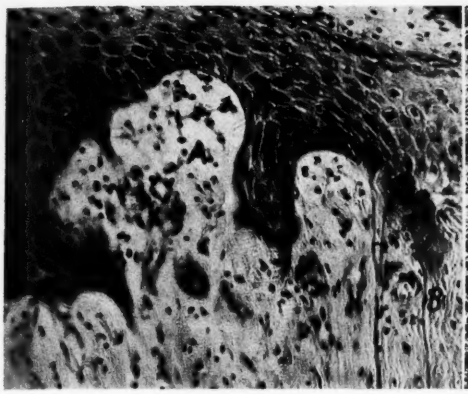

Fig. 1. The focus of localized edema below the epidermis, the round-cell infiltration, and the disarrangement of the corium characteristic of the lesion.

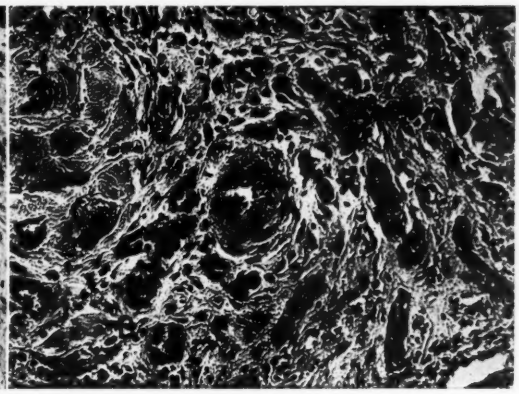

Fig. 2. An obliterated arteriole and what begins to look like nests of cells.

bach believes may be the development of carcinoma.

SYMPTOMATOLOGY

There is usually a period of incubation of the burn during which no effects are manifest although, in some of Pfahler's cases (19, 20, and 21) of abdominal burns, nausea and vomiting were observed within a few minutes after exposure. In cases of x-ray dermatitis among professional men Cole (26) found: (1) that there are no symptoms for an indefinite period; (2) that the hands become dry, and there is a loss of the touch and temperature sense; (3) the grip is weakened; (4) there is pain, especially at night, sufficient to prevent sleep. In the first degree burns, there is depilation, burning (occasionally severe enough to be called pain), atrophy, and telangiectases. The second degree burns, in which the pain is much more severe, show the above symptoms intensified, vesiculation, and also there is present a raw sensation. In burns of the third degree, all of the symptoms are still so much more pronounced that there is loss of function and finally actual necrosis. The pain in this type is intense, making morphine addicts of some of the patients, and it is believed to be due to: (1) irritation of the nerve endings by infection; (2) changes in the nerves caused by rays, or progressive obliteration of the blood vessels; (3) pressure on the nerves by the scar. Davis (22) believed that one or all of these were the cause. Occasionally there may be marked subcutaneous edema and ankylosis if the burn has affected the jaw or knee as in cases of Bevan (13) and New (24). Many of the burns produce loss of function by pain or swelling, and, in burns of the anus, this loss of function may produce a variety of additional subjective symptoms. Since the burns produce so much disfigurement and scarring, nervous symptoms are fairly common. A profound neurasthenia may develop. Michael (25) says that x-ray burns are cosmetically offensive; may give rise to distressing subjective symptoms; may disturb function, and are potentially malignant.

TREATMENT

Some writers prefer the use of actinic or ultra-violet light in the active treatment of roentgen-ray burns, but the majority feel that this form of treatment has little or no value and that, since the original damage is a proliferative endarteritis, further irradiation will only aggravate the condition. The delay necessitated by such treatment causes much unnecessary pain and may give sufficient time for the beginning of malignant degeneration. The cases of New (24), Porter (4), Davis (8), Cole (17),

Blair (32), Desjardins and Smith (10), Barrow (33) and others, show that the type of treatment generally used for roentgen-ray burns is palliative until surgery is required or thought indicated. In the less severe burns and the early stages of the severe third degree burns, many lotions and ointments have been tried, most of them with little success. Dodd's solution, made up of phenol 1.85 c.c., zinc oxide 15.5 gm., glycerin 4 c.c., and lime water to make 250 c.c., has been found to give some relief when daubed on with cotton and left to dry. No caustics, irritants, or antiseptics are indicated unless there is a severe infection and then hot saline compresses may give much relief and improve circulation. A useful measure in first degree burns is the spraying on of paraffin films or mixtures such as balsam of Peru 4 c.c., castor oil 2 c.c., Venetian turpentine 2 c.c., and alcohol to make 100 cubic centimeters. To remove sloughing and necrotic tissue from an ulcer, Dakin's or hychlorite solution 1/20 or 1/30 is recommended. The hychlorite is believed to be superior because of its more constant chemical qualities. For recalcitrant lesions, surgery must be undertaken. Porter and White (26) feel that all ulcerations which, under ordinary treatment, remain open after three months should be thoroughly excised and very carefully examined. The subsequent treatment depends on the result of the microscopic examination: there should be skin grafting, further excision and grafting, or amputation. Keratoses should be removed by electro-dessication or coagulation. In excision of a burned area, one must go beyond the visible limits of the burn, since much of the damage is microscopic and extends further than one is led by gross inspection to believe. Wide excision is the only sure way of relieving the pain. Skin grafts should be applied to the excised area immediately, if there is a certainty that all damaged tissue has been removed. If doubtful tissue is left, owing to the impossibility of complete excision due to its involving nerves, arteries, tendons, or the whole thickness of the abdominal or chest walls, the grafting should be deferred until there are granulations. The type of graft used is determined largely by individual experience. New (24) feels that the tube flap gives a better cosmetic result and better color than the full thickness graft. Bevan (23) uses primary excision and closure in acceptable cases, such as in burns of the anus. Reverdin, Thiersch, full thickness, and flap grafts have been used by different men with good results.

PREVENTION

In the prevention of x-ray burns, Davis (27) recommends: The further education of those using the x-ray as to its dangers; a better protection for the patient and the operator, and education of the public. There should be a limitation of the indiscriminate sale of x-ray machines and apparatus, as many burns have occurred (Hazen, 28) from their use in beauty shops. Pfahler (19) and Tousey (29) stress: careful measurement of timing, notice as to milliamperage and filtration, detailed and complete records, a device to prevent the omission of the filter, and attention to the fact that patients be reminded not to use irritants following the x-ray. For roentgenologists, the carrying of an unexposed dental film in the pocket for two weeks at a time is recommended to determine if their protection is adequate.

The following group of cases of x-ray burns were referred to the surgical service of the University Hospital during the period from 1907 to 1933. None of these cases received roentgen therapy or diagnostic irradiation at this hospital.

Case 1. W. C. E., was admitted on Aug. 29, 1907, and discharged on Oct. 16, 1907. The patient was diagnosed as having x-ray burns of the hand, and gave symptoms of pain, deformity, and loss of function. After amputation of a finger, the condition improved.

Case 2. M. T., female, 30 years of age, was admitted on Nov. 11, 1918, and discharged on Nov. 20, 1918 (9 days). The

patient had burns of the anterior surface of the chest and lower part of the neck. Seven years before she had had x-ray treatments for Hodgkin's disease; one treatment daily for a month and two treatments a week for two years. About five years prior to her admission to the hospital, her chest began to blister. There was intense pain, itching, and the skin of the chest was red and hard. Following the cleaning of her chest wound, and a graft on Nov. 12 which seemed to take, the patient was discharged, having improved considerably.

Case 3. E. C. T., male, 40 years of age, was admitted on March 15, 1919, and discharged on April 17, 1919 (33 days). The patient had an x-ray ulcer of the back. On Jan. 10, 1919, he had had a gastrojejunostomy, following which he had prolonged fluoroscopic examinations. An ulcer developed and gave pain of an intense character which could be quieted only with heroin. On March 21, 1919, the ulcer was excised, and his recovery was uneventful.

Case 4. R. W., female, 37 years of age, was admitted on Jan. 5, 1927, and discharged on May 5, 1927 (120 days). Following a complaint of excessive bleeding at the time of her periods, the patient was given two deep exposures of x-ray to the abdomen which lasted 25 minutes each, a treatment which caused nausea and vomiting. Two weeks later, she was given one treatment to her back which lasted an hour and a half. Two weeks later she began to have itching of the skin, a mahogany color, and sloughing. The pain was so severe that heroin in quite large doses was required. Butescin pictrate relieved the itching. An Alpine lamp (used in 1926) caused irritation and fever. On admission to the hospital, the ulcerated area was about 15 cm. in diameter. Dakin's solution, phenol dressings, and mercurochrome, 1 per cent, were used to cleanse the wound. On Jan. 8, Jan. 13, and Jan. 20, 1927, skin grafts were taken from the thighs. An infection developed and saline dressings were employed. In seven months, four débridements were done upon the ulcer on the back. The patient was given phenol ointment for the relief of pain locally. On March 1 and March 19, 1927, Thiersch grafts from the thighs were done, and on April 8 and April 11, 1927, pinch grafts were done. An infection of the area (believed to be *Bacillus pyocyaneus*) hindered the success of many of the grafts. On April 27 and again on May 5, 1927, other grafts were done, which covered all but a small area and which took successfully, the patient being sent home greatly improved and with no pain.

Case 5. J. P., male, 24 years of age, was admitted on April 25, 1927, and finally discharged on Oct. 27, 1927, a total of 118 days. Between these dates, he had been re-admitted twice. Following a treatment course for eczema five months before admission, a second degree burn had developed, which had healed and sloughed out. There were contractures and the wound was very tender, being especially painful when the patient was walking. The sloughing in the affected area had exposed the tendon. On May 12, 1927, a débridement was done to relieve the patient, who suffered considerable pain. Following this, he was treated with Dakin's solution, antiphlogistin, and boric acid, with no improvement. Curettement was then advised. On June 30, 1927, a large skin flap, three inches in diameter, the upper end of a Gillies tube graft, was attached, unsuccessfully. Ultra-violet radiation was recommended, but this resulted in no improvement. On Sept. 10, 1927, a skin graft of the Reverdin type was done, and two days later, the femoral artery was exposed and stripped of the sympathetic nerve fibers. On Oct. 18, 1927, six small pinch grafts were applied to the involved area, which took successfully. Bier's hyperemia was suggested, and applied without much success. On his discharge, the patient still had a chronic ulcer.

Case 6. J. P. L., male, 37 years of age, was admitted on May 17, 1929, and discharged on May 26, 1929, a period of 9

days plus hospitalization at another hospital. Seven months before admission, the patient had run a needle into his palm. X-ray films were made and fluoroscopic removal was attempted for seven or eight minutes, at a distance of six inches. Two more roentgenograms were taken and the fluoroscope was again applied for from three to four minutes. Five days later, the hand began to swell, broke down, and discharged pus. A chronic ulcer developed over the base of the third, fourth, and fifth fingers. On May 18, 1929, a débridement was done and the involved section showed a chronic ulceration, with granulation and necrosis, also considerable epithelial hyperplasia at and beyond the edges of the ulcer. There was no true malignancy. Dressings of mercurochrome, 2 per cent, and Dakin's solution were tried. The patient was discharged at his own request on May 26, 1929. A follow-up note on Aug. 18, 1929, stated that he had gone to a hospital in New Jersey where an amputation was done, leaving only the thumb. The wound had healed, and he had no pain.

Case 7. R. W., female, 43 years of age, was admitted on June 16, 1931, and discharged 30 days later. Seven years previous to her admission to the hospital, the patient had had roentgen-ray treatments for fibroids, which lasted about a year. Three years before admission, a large blood vessel broke in the affected area, and she has had severe burning pains and a small ulcer on the abdomen, about the size of a ten-cent piece. A wide excision was done and five pieces of skin from the right thigh were grafted onto the involved area. These sloughed out, but a second graft was done which proved to be more successful. On discharge from the hospital, the patient still had a very small wound.

Case 8. J. G., male, 52 years of age, was admitted on Nov. 24, 1931, and discharged on Dec. 18, 1931, a total of 24 days. The patient had had psoriasis for 21 years prior to his admission. Seven years before his admission, he had x-ray and lamp treatment for three years. Following the last treatment an area of "scorching" was present on his chest. This area was tender and painful and later became ulcerated. It healed to about the size of a quarter but would break down following any trauma. After a slight trauma five months before admission the ulcer broke down and became about the size of an orange. There was much pain—even the touching of the ulcer by the clothing caused discomfort and a sero-sanguineous discharge. The patient was treated by a wide excision of ulcer and scar from his chest and one week later a Thiersch grafting was done. The wounds were dressed with white vaseline gauze which had previously been irradiated under a Mercury Arc Light for one and a half hours at a distance of eight inches. The majority of the grafts had taken at the time of discharge. Six months later, the ulcer which biopsy had proven to be spinocellar carcinoma had broken down again.

Case 9. H. D., male, 23 years of age, stated, upon his admission to the hospital, that eight months previous a small piece of steel entered his knee region. It was located under the fluoroscope and removal was attempted at the time. The patient further stated that he was in the fluoroscopic room for about an hour and a half. About a week later, the skin began to darken as if sunburnt. It then became sore, the skin pores turned purple, vesicles formed, and an area about four inches in diameter sloughed out. It is healed up to about one inch in diameter but has sloughed out again. Almost all types of ointments have been used without success. The patient had been treated in the hospital with wet sulphen dressings, alternating with boric acid dressings. A radical excision was done on Feb. 11, 1933, leaving a fairly healthy granulating base. The wound was dressed and the edges were protected with paraffin gauze. Three days later a full thickness skin flap was patterned on the thigh above the ulcer, to be turned down in about five days, and on Feb. 18 this flap was brought down over the upper half of the ulcer. It did not

take well, but became black and gangrenous at its margins, though the rest of the flap, at the top of the wound, did well. Below this area the wound sloughed out and showed unhealthy, necrotic margins, with a fibrous, white, and avascular base. Very little granulation seemed to take place over this area and pain was still present to a marked degree. This was the condition at the time of the writing of this paper.

All of them had pain as the most prominent symptom, loss of function and disfiguration being the next symptoms of importance. A long series of exposures caused five of the burns, while three of the others were due to a single great over-exposure. In seven cases, palliative measures were tried before surgery, with poor results. In two cases ultra-violet light was used with no result. In one case there was a severe reaction to this form of treatment. The result of surgery was clinical cure in seven cases. In one of the others, the result was improvement, and in the other malignant degeneration had occurred before the ulcer was treated. The type of surgery used was excision and Thiersch grafts in three cases, excision and Reverdin grafts in two cases, excision and full thickness graft of the flap type in two cases, and amputation in two cases. The average number of days of hospitalization was 39, a figure which is necessarily low because of the nine patients—four were treated in other hospitals after their discharge. The surgery used must depend largely on the location of the burn, looseness of adjoining tissues, thickness of the tissues, and the blood supply.

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TABLE I.—CHART OF ALL CASES TREATED AT UNIVERSITY HOSPITAL FROM 1907–1933

Case	Sex	Age	Etiology of burn	Location	Treatment	Result	Hosp. days
W. C. E.	Incomplete records			Burn of hand	Amputation of finger	Good	19
M. T.	Female	30	Treatment for Hodgkin's disease	Ant. surface of chest and neck	Excision of ulcer Reverdin graft	Good	9
E. C. T.	Male	40	Fluoroscopic examination	Ulcer of back	Excision	Improvement	33
R. W.	Female	37	Profuse menorrhagia	Ulcer of back	Excision of ulcer Thiersch graft	Improvement	120
J. P.	Male	24	Treatment for eczema	Left popliteal space	Débridement and Reverdin grafts	Result poor	118
J. P. L.	Male	37	Fluoroscopic removal of foreign body	Base of 3rd, 4th, and 5th fingers	Amputation	Good	9
R. W.	Female	43	Treatment for fibroids	Ulcer of abdomen	Excision and Thiersch grafts	Improvement	30
J. G.	Male	52	Treatment for psoriasis	Ulcer of chest	Excision and Thiersch grafts	Carcinomatous degeneration	24
H. D.	Male	23	Fluoroscopic removal of foreign body	Lateral aspect of right knee	Excision—full thickness flap graft	Improvement	86 to date

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A ROENTGENOLOGIC CONSIDERATION OF THE ARTHRITIDES

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ARTHRITIS may be defined as a generalized disease, with joint manifestations. No single infectious or traumatic condition may cause this disease, no metabolic disturbance, but some variation of all these may combine to be a factor in its causation.

Much confusion is apparent in the terminology in that "degenerative arthritis" is also described as "hypertrophic," and "proliferative" is designated as "atrophic." This contradiction is due to the fact that one group bases terminology on changes in soft parts, whereas the other group bases it on bone changes.

Before dealing with the pathologic processes which involve the joint, we might well remember its normal parts, namely, its articulating surfaces composed of cartilage, the synovial membrane, synovial fluid, and ligaments. Neither periosteum nor free bone is normally found in a joint. The diagnosis of a joint condition is accomplished by carefully considering the changes in one or more of its component parts, of which the cartilage is probably the most important. The various chronic conditions met with in arthritis are due mainly to the involvement of the cartilage.

Many infectious types of arthritis seem to involve the synovial membrane, with increased changes in the amount of synovial fluid. In these types of joint infection a return to the normal condition may be reasonably hoped for, while, when the cartilage is involved, the return to normal condition depends largely upon the degree of severity of the infection. It is known that cartilage reproduces itself to a limited degree only, and if a portion is completely destroyed down to the bone, Nature replaces it either with fibrous or osseous tissue. It is in this manner that what may be called "free bone" in a joint is developed.

For a roentgen consideration of the arthritides, we will classify arthritis as to:

I. Traumatic Type
II. Infectious Type
III. Atrophic Type
IV. Hypertrophic Type.

I. Traumatic Type.—This type exhibits the picture of capsular distention, with increase in synovial fluid. It differs little from the first stage of an infectious process in which a swelling of the soft tissues exists. However, if continued over a long time, destructive and productive changes occur in the joint. Traumatic joints are usually seen as occupational injuries (for instance, in riveters); they result in postural deformity due to repeated injury to the joint surface, and they are seen in injuries of bone in which trauma causes proliferation.

The injury may be of any one of several types:

(1) A single severe injury to the joint cartilage;
(2) Repeated mild trauma to the joint cartilage;
(3) Disorganization of the mechanics of a joint;
(4) Faulty weight-bearing on account of bony deformity so that use brings about repeated injury to the joint surface;
(5) Gradual deformity of a joint by abnormal pressure.

II. The Infectious Type.—This type includes tuberculosis, gonorrhea, syphilis,

Fig. 1. Traumatic arthritis. Dorsal ventral view of foot showing union at metatarsal phalangeal joint of big toe due to trauma (see arrow). Patient kicked a large stone by mistake, resulting in bony union after which followed traumatic arthritis.

pneumococcic infections, etc., and those types of arthritis which have the same clinical manifestations, though the exact etiologic factor is unknown. This group does not seem to be limited to any age period, and is as prevalent in the second as in the third age period. It is true that certain acute infections, such as gonorrhea or tuberculosis, are more common in the second age period.

The first change to take place is swelling of the synovial membrane. In the majority of affected joints, the flesh and skin outline will indicate this by the enlargement of the soft tissues. With this inflammatory change of the synovial membrane, fluid will form; in most joints one can infer this by the position of the part and the swelling around the joint. In the case of the knee, the riding patella will be seen. If this infection is severe, the next point of attack will be the cartilage. Here also the structure is not demonstrable by the x-ray and again the condition must be determined by indirect evidence; that is, the width of the joint space. If the cartilage is uniformly eroded, the joint space will be narrowed. The infection may go on to complete destruction in certain areas and attack the bone beneath. Immediately the bone becomes involved there is direct evidence of destruction that can be demonstrated upon an x-ray plate.

From an x-ray standpoint, infectious arthritis presents three different appearances, according to the stage of the disease at the time of the examination. In the first stage, at the onset of the infection, the plate shows distinct swelling of the soft tissues around the joint, with increase of synovial fluid. That there is no cartilaginous destruction is evidenced by the fact that the joint spaces are of normal width. Since the cartilage has not been involved, of necessity there can be no bone change. There is no atrophy, as sufficient time has not elapsed to bring about this condition. This stage gives the same x-ray appearance as an acute polyarticular rheumatism or an injury to the joint without fracture, because in those conditions fluid and periarticular swellings are also present, and no cartilaginous changes appear.

In the second stage the disease probably reaches its maximum intensity and in time changes take place in the joint and bone. When sufficient time has elapsed for the joint to become more or less immobilized, either from pain or treatment, consequent atrophy of the bones forming the joint appears. The swelling and fluid are still

present. The cartilage in this stage has become involved and may be more or less destroyed, according to the severity of the infection, evidenced by the fact that the joint space is narrowed. The infection may have localized sufficiently at one part of the joint to destroy all the cartilage and actually involve the bone beneath; in this event any bone change can be easily seen upon the plate. While the soft tissues around the joint are still swollen, there may be atrophy of the soft tissues above and below the joint, particularly true in long-standing infections, such as tuberculosis. This second stage is variable as to length of time, and the same changes persist as long as the infection is active. The atrophy, however, becomes greater the longer the acute stage exists. There is no production of new bone, as this is a repair process and cannot take place during the height of the disease.

With the subsiding of the infection, the third stage, or the stage of repair, is ushered in. Here too, the picture is slightly different, depending upon whether the examination is made at the beginning or at the end of this stage. The swelling and fluid have disappeared, the atrophy is still present, and will disappear only when the joint begins to function again. The destructive process, however, has ceased and repair now takes place. Unfortunately the cartilaginous surfaces which are so easily attacked have little recuperative power in themselves. Cartilage reproduces itself to only a limited extent, and so Nature has to fall back upon two substitutes: the destroyed area is either filled in with fibrous tissue or the raw, exposed bone proliferates, filling up the destroyed area. This overgrowth is spoken of as exostosis and its extent is dependent entirely upon the extent and severity of the infection. Where two opposing articulating surfaces are denuded of cartilage, the resulting new bone formation from both surfaces may unite and produce actual bony ankylosis. It is interesting to note that the infection or its toxins shows a marked predilection for the ligamentous attachments, and the first bone proliferation is found in these points.

III. Atrophic Arthritis.—In a study of 62 cases conducted by us, we found the atrophic type of arthritis, with its cartilaginous destruction and ankylosis, predominant in tall, poorly developed, slender, visceroptotic individuals, and in females. In the latter, pain, disability, and deformity seem to be the chief complaints.

The atrophic lesions are generally seen from birth to middle life. The x-ray examination shows marked atrophy of both soft tissues and bone, and the joints are frequently partially ankylosed due not to bone but to fibrous changes and muscle contracture. There is extensive absorption of cartilage, even to the point of its complete destruction in certain areas, but apparently Nature makes no attempt at new bone formation. There is a thinning or destruction of the joint cartilage, with atrophy of all soft tissues and bone from disuse. Though there is no new bone formation as a rule, frequent subluxation of the joint due to tendon contraction is seen with lack of motion due to fibrosis and contracture. The earliest pathologic change is proliferation of the synovial membrane, which is not definite in roentgenograms, but, the marked osteoporosis and decrease in density of the bone ends give the appearance of atrophy in the x-ray plate.

In the atrophic type of arthritis, we note an early proliferation of the synovial membrane, with erosion of the articular cartilage and pannus formation. Finally, destruction in the articular cartilage takes place, with fibrous or bony ankylosis. It is in this type of arthritis that motion is essential in the treatment of the joints. When the joint has recovered as far as possible there is absence of swelling and fluid, atrophy has disappeared, followed by the marked formation of exostosis or actual bony ankylosis, depending entirely upon the severity of the lesion.

IV. Hypertrophic Type.—This is a disease almost invariably associated with individuals of middle and old age, since

Fig. 2. Infectious arthritis. Case 1. Patient, aged 54, with streptococci infection. Roentgenogram shows condition of right ankle joint on Feb. 10, 1931, two days after onset of infection.

Fig. 3. Shows the right ankle joint on Feb. 16, 1931. Note the progressive intra-articular destruction.

Fig. 4. Shows the same ankle joint on Feb. 23, 1931. Note the areas of destruction and absorption of cartilage and bone, with narrowing of intra-articular space.

one rarely sees it in those under forty, and it is most pronounced in patients in the neighborhood of fifty and over—the third age period. Attention has already been drawn to the fact that as we grow older there is a generalized atrophy of all the bones, which we look upon as normal change due to old age. Consequently, since this disease is one of old age, one would naturally expect to find atrophy in hypertrophic arthritis; on the contrary, however, the x-ray examination shows no atrophy and apparently an increased deposition of calcium, so that the bone shadows are even a little more dense than normal.

There is no swelling or fluid in the joint. The cartilage is destroyed in focal spots in these areas, bony exostoses appear, and there is marked new bone formation at the attachments of the ligaments of the joints. Frequently small bony bodies lie free in the joint cavity, and these "joint mice" may become engaged in the joint, resulting in swelling and fluid, but this is an accidental factor and not one to be met with in the normal course of the disease. There may be ankylosis of the joint—not a true ankylosis due to fibrous tissue or bone union, but simply a mechanical locking of opposite engaging exostoses. This type simulates the third stage, or the stage of repair, in an infectious arthritis. The two conditions, however, would only be confused in old persons, since the Hypertrophic Type does not exist in the second age period.

In the cases of the hypertrophic form studied, we found that the majority of

lesions were in the lumbar region, and became progressively fewer as one ascended the vertebral column. Therefore, in the case of a heavy, well-developed individual, it seems that those segments which are under the greatest mechanical stress undergo the greatest amount of strain and lipping.

As Pemberton concisely says, the peripheral circulation becomes greatly slowed up in hypertrophic arthritis, with the resultant formation of fibro- and chondro-osseous spicules deposited in various sites. We noted a strong tendency for the ligamentous structures about a joint to become ossified, with marked diminution of function in the joint. In time, these structures become more and more susceptible to injury and recover more slowly in the event of subsequent trauma.

Chronic Osteo-arthritis.—The earliest change consists of the formation of osteophytes at the articular margins. These osteophytes are smooth in outline, usually fairly regular and rounded in shape, and may attain considerable size. When large, they frequently become detached as a result of minor injury, and may in some cases form intra-articular loose bodies. Concurrently with the osteophytic formation, gradual erosion of the articular cartilages takes place, evidenced in the roentgenogram by a narrowing of the joint space. In time, the underlying cortex is eroded, but this destruction is counterbalanced by subcortical sclerosis, producing the dense, eburnated surfaces so characteristic of advanced osteo-arthritis. Bony ankylosis practically never takes place, because of this.

In hypertrophic arthritis there is increased density of the bone. Therefore, in this condition, a lime salt deposit occurs in the form of chondro-osseous spicules at the articular margins, which become definite in a roentgenogram. No atrophy of either bone or muscle controlling the joint occurs until very late in this condition.

Briefly, to summarize the difference between these different conditions the following points are to be borne in mind: Atrophic arthritis is seen largely in the second age period, hypertrophic arthritis in the third age period, while infectious arthritis occurs in any age period.

Arthritic Changes Due to Age.—Great care must be taken not to confuse the slight changes which are always present in old persons with acute active processes. It has been definitely established that practically all of us, when we reach the age of 45, show a small exostosis in and around the joints, particularly where the ligaments attach, and yet there may be no clinical manifestations of an arthritic process. This naturally means that there is a quiescent arthritis present, which needs only the proper stimulation to become an active process. It is in just such cases that marked symptoms follow a slight injury, symptoms out of proportion to the extent of the injury. In this condition we must remember that the injury has simply lowered the resistance of the joint and has allowed this quiescent arth-

TABLE I.—SIXTY-TWO CASES STUDIED FROM 1928–1930

	No.	Status	Location	Age	Sex
Traumatic arthritis	5	Stocky persons; well developed	85% knee 10% ankle 5% scattered	Any age	
Infectious arthritis	8		55% shoulder joint 35% elbow joint 10% scattered	Any age	
Atrophic arthritis	11	Ptotic, slender, tall, poorly nourished	60% ankle 20% knee 20% other parts	From 2 to 38 years	85% Female 15% Male
Hypertrophic arthritis	38	Well developed; heavy; sluggish	20% knee 70% lumbar spines 10% scattered	From 40 to 75 years	58% Female 42% Male

ritis to flare up into an active process, really the result of the arthritis and not of the trauma.

Since arthritis is a systemic disease, it has prodromes that the joint manifestations are only local expressions of the systemic disturbances and that the processes may manifest themselves elsewhere.

The atrophic type of arthritis can be produced experimentally, by injecting the joints of rabbits with streptococci. On the other hand, the hypertrophic type cannot be produced experimentally with bacteria, but it can be produced by introducing a foreign body into a rabbit's joint. This seems to prove that atrophic arthritis is bound up some way with trauma or the wearing out of a joint, *i.e.*, it is a degenerative process. The importance of this point of view from the standpoint of treatment is great. It means that in atrophic arthritis, one's efforts should be directed first to the removal of all foci of infection, after which one should proceed to build up the patient in a constitutional way, whereas, in the hypertrophic type, one need not perhaps be so eager to remove the foci, but first to direct attention to resting the joint, relieving strain and giving support.

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ANIMAL EXPERIMENTS WITH COLLOIDAL THORIUM: A STUDY IN LYMPHATIC ABSORPTION[1]

By RAPHAEL POMERANZ, M.D., *Newark, N. J.*

THE introduction of colloidal thorium into commercial use under the name of "thorotrast" aroused many hopes in the field of radiologic diagnosis of diseases of the liver and spleen. I became interested in the subject in the early months of 1932, and decided to study the value of colloidal thorium in radiologic visualization of lymphatics of the abdominal cavity. This necessarily led to a comparison of findings in the intravenous and intraperitoneal use of the colloidal metal, and further comparison of these findings with those obtained by a simultaneous intraperitoneal injection of colloidal thorium with other substances, namely, pure silica, as SiO_2, known as a colloidal poison.

EXPERIMENT 1 (R1)

Twelve c.c. of thorotrast, diluted in ten c.c. of sterile saline, was injected intravenously into a rabbit that weighed four pounds. Exposures were made from then on, at first daily and then weekly, until the time of autopsy which was performed 60 days after the injection. As long as the rabbit lived, no ill effects could be noted, judging from the behavior of the animal.

X-ray Findings.—Twenty-four hours after the injection, the liver and spleen were visualized, casting a dense shadow when compared with the film taken before the injection. The spleen showed a granular structure and was much more dense than the liver. The shape and size of the spleen changed with each exposure, according to its position and contractility (Fig. 1). An intra-abdominal injection of thorotrast was also attempted on the same rabbit. The thorium was deposited in the muscular wall and after a few weeks

Fig. 1. Experiment I, 24 hours after intravenous injection: (*a*) spleen; (*b*) liver.

could be seen spreading in both directions. Some of the regional inguinal glands were visualized. At the autopsy, the following organs and parts were removed and x-rayed immediately after removal: liver, spleen, kidneys, testicle, adrenal glands, heart and lungs, a piece of rib, and the left femur. There was evidence of the dye on the films in the spleen, liver, lungs, and bone marrow.

Microscopic Findings.—A small amount of thorium was found in the lung, bone marrow, and adrenal gland, the largest amount being in the lung. None was seen in the kidneys and testicle. The spleen (Fig. 2) was packed with thorotrast in the

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

form of clustered granules, situated in the perilymphatic spaces and in the pulp. Occasional thorium patches could be noted

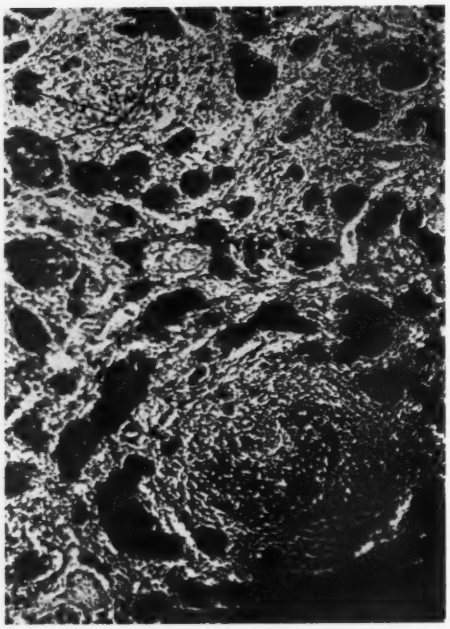

Fig. 2. Experiment I, spleen, 60 days after intravenous injection: (*a*) large clumps of thorium filling the reticulo-endothelial cells to capacity. Some of them are arranged around the lymphatic centers.

in the center of a lymphatic follicle. No definite degenerative changes due to radioactivity could be found in the lymphatic centers of the spleen. The liver (Fig. 3) contained the bulk of the thorium particles. It was taken up by the reticulo-endothelial cells in the form of fine granules. The parts of the liver lobules which contained the bulk of thorium particles, as above described, show definite advanced degenerative changes; the liver cells lost their color, their nuclei are dense, pycnotic, and their protoplasm is retracted. The periportal fields show only occasional thorium containing cells. The liver cells around the periportal fields preserved their normal color and appearance.

EXPERIMENT 2 (R2)

Under fluoroscopic guide, 20 c.c. of undiluted thorotrast was injected intraperitoneally into a rabbit that weighed about four pounds. Five c.c. of the substance was lost in the skin and muscles of the abdominal wall. Immediately after the injection, a fluoroscopic examination showed a rapid distribution of the thorium throughout the peritoneal cavity. Plates were taken at short intervals of from 3 to 100 minutes after the injection, following which more serial plates were taken from 24 hours up to five months.

X-ray Findings.—For comparison, a plate of the abdomen was taken before the injection. Three minutes after the injection, the film shows rapid distribution of the thorium throughout the entire peritoneal cavity; some of it can be seen penetrating through the mesenterial and omental lymphatics into the upper surface of the diaphragm. This process of upward absorption can be seen progressing on the film, taken 15 minutes after injection. Films taken 50 and 100 minutes after injection (lateral views) show the thorium outlining the pleural surfaces of the diaphragm, also a suggestion of linear lymphatic vessels behind the sternum, and an accumulation of thorium in the upper anterior chest just behind the manubrium sterni, of about 2×3 mm. in size.

Twenty-five hours after injection, plates were taken in the postero-anterior and lateral positions. In the chest, the lymphatic vessels behind the sternum are much better visualized, showing increased density. The same applies to the areas of accumulation of thorium in the upper chest, which are apparently situated around the jugular veins and represent large lymphatic sacs or cisternæ. The abdominal cavity shows a better definition of the mesenterial lymphatics, also an outline of the peritoneal lining. All the lymphatic sacs in the abdomen show large clumps of thorium, particularly those below the liver. The liver and the spleen are of increased density. The spleen is

particularly dense and has a granular appearance.

Fifty-two and 74 hours after injection, the films show further progress in the absorption of the thorium from the peritoneal cavity, as above described.

Twenty-two days after injection, plates show a distinct diminution of the amount of thorium in the abdominal mesenterial lymphatics. The last ones are sharply defined; the peritoneal lining is sharply outlined. This process of re-absorption of thorium from the peritoneal cavity goes on further, as one can see on the follow-up plates taken 48 days and finally 155 days after the injection, giving a very sharp outline of the peritoneal lining with all of its pouches (for pancreas and rectum), and of the mesenterial lymphatics. The lymphatic cisternæ in the chest are now smaller but of greater density. Most of the thorium that was lost in the muscles of the abdominal wall spread downward. Some of the lymph glands in the right axillar region were visualized.

The animal having been embalmed, an autopsy was performed five months after the injection. The site of injection was examined first. The thorium could be seen extending below the skin, through the muscles on the right side of the abdominal fascia, and downward toward the right inguinal region. At the point of the injection, a hard nodule of thorium could be palpated. Glands in the right axilla and alongside the right chest wall could also be palpated. On opening the peritoneal cavity, the thorium could be seen distributed over the entire peritoneal lining, forming a fine network, and consisting of small thorium granules. Also, several small cysts, surrounding clumps of thorotrast, could be noticed. On transillumination, the mesenterial lymphatics could be clearly seen as very fine white to gray lines. The arteries and veins stood out distinctly in the mesentery, filled with the gray colored lymphatics. The following organs were examined: glands, from chest and axilla; sternum, with the mammary vessels, and lymphatics; diaphragms; abdominal wall; mesentery with cysts; adrenals; kidneys; thymus and ovaries, and lungs.

Fig. 3. Experiment I, liver, 60 days after intravenous injection: (*a*) thorium granules in the reticulo-endothelial cells; (*b*) pycnotic dense degenerated nuclei of the liver cells.

Microscopic Findings.—The bulk of the thorium was seen in the lymphatics of the peritoneal lining and mesentery. These lymphatics were situated mostly around the vessels. The thorium granules appeared like drops in the flattened cells, the nuclei of which could hardly be discerned. The thorium was also seen in the capsule and cover of the spleen, diaphragms, liver, and of all the other intra-abdominal organs. Next in amount, the thorium was present in the spleen, the distribution of which is similar to the one above described in R1 (Experiment I). There is, however, a smaller amount of thorium present than in R1. A comparatively small amount of thorium was seen in the liver, distributed in the same way as in R1. There is no evidence of degenerative changes of the liver cells in this case. The thorium was further found in the anterior chest wall (anterior mammary lymphatics), in the lymphatic sacs of upper chest, also in the capsule of the adrenals, in the abdominal wall, and

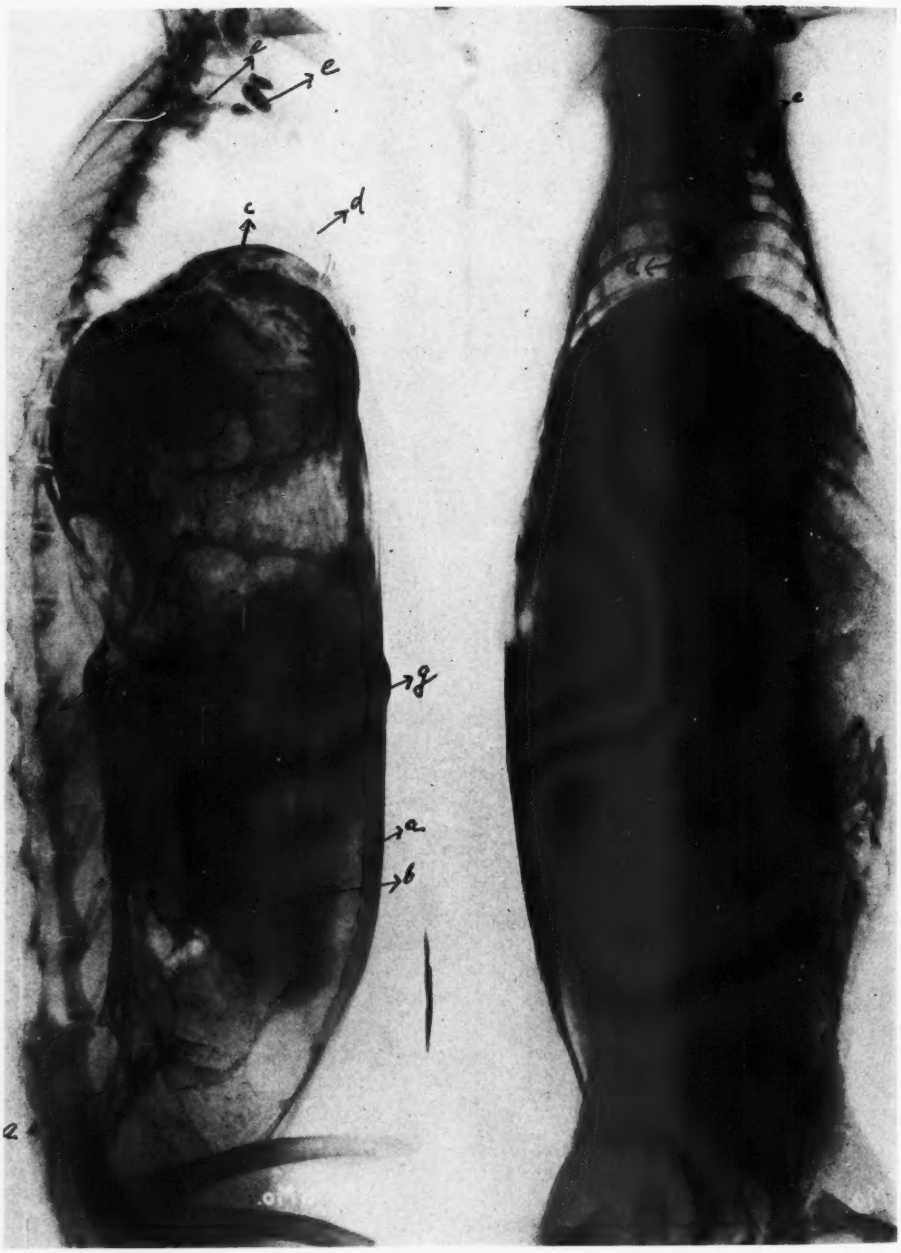

Fig. 4. Experiment II, 155 days after intraperitoneal injection (postero-anterior and lateral views): (*a*) peritoneal lining and peritoneal lymphatics; (*b*) mesenterial lymphatics; (*c*) diaphragmatic lymphatics; (*d*) anterior mammary lymphatics; (*e*) large lymphatic sacs in the mediastinum; (*f*) spleen; (*g*) thorium in the abdominal wall.

axillary lymph nodes. No thorium was seen in the ovary or thymus or kidneys. Due to embalming, the pulmonary alveoli were filled with fluid which made the sections not useful for diagnosis.

EXPERIMENT 3 (R3)

Ten c.c. of thorotrast and one gram of pure silica[2] dust dissolved in ten c.c. of water was injected intraperitoneally in a rabbit, weighing about three and a half pounds. No ill effects could be noted from the injection during the lifetime of the animal. Plates were taken before and 15 minutes after injection. This was followed up by plates taken 24 hours, six weeks, and three months after the injection, the last ones taken just before the autopsy.

X-ray Findings.—Plates taken 15 minutes after the injection show a diffuse spreading of the metal throughout the peritoneal cavity with upward absorption, pointing to the diaphragms. The absorption from the peritoneal cavity is much faster than in R2 (Experiment II). This could be seen on the film taken 24 hours after injection. The anterior mammary lymphatics appear very thick and dense on these films, indicating a much faster rate of absorption. Films taken six weeks and three months after injection (Fig. 5) show a much smaller amount of thorium in the peritoneal cavity than in R2. The peritoneal lining and the mesenterial lymphatics are visualized, but not as well as in R2. A large amount of thorium was present in the lymphatics of the large omentum. The spleen, however, is well visualized; the liver is of increased density.

Autopsy Findings.—The autopsy was performed a little over three months after the peritoneal injection. The peritoneal cavity shows much less thorotrast, both in the peritoneal lining and in the mesentery, than in R2. A great deal of thorium was accumulated in the large omentum. In certain places, the thorium could be found forming small lumps in the peritoneum. Lungs showed no consolidations that were palpable; they were of pinkish gray color and in places showed white spots under the pleura. The following specimens were removed: abdominal wall including the peritoneal lining; liver; spleen; testicle; large omentum with nodules of thorium and pancreas; kidneys; adrenal glands; diaphragms; sternum; trachea; lungs and heart; lump of thorotrast from the chest; femoral artery and tibia, and bone marrow.

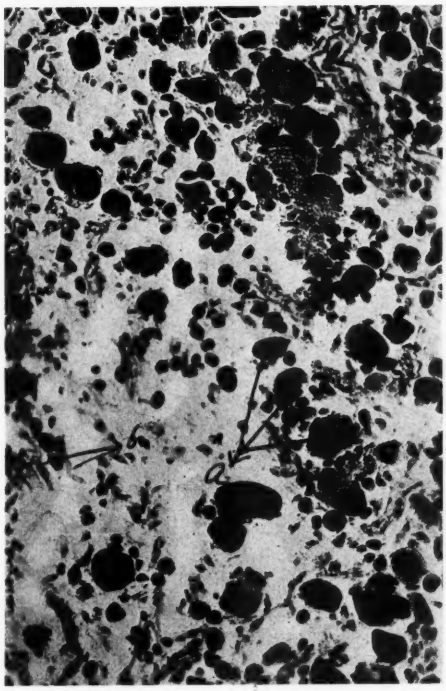

Fig. 5. Experiment II, mesenterial lymphatics: (*a*) thorium granules in the reticulo-endothelial cells; (*b*) loose fibrous tissue.

Microscopic Findings.—The largest amount of thorium could be found in the spleen, liver (Fig. 6), bone marrow, and abdominal lymph nodes. There was less thorium in the mesenterial lymphatics than in R2. There was also less in the lymphatics of the diaphragms. No thorotrast could be seen in the kidneys, adrenals, testicle, and pituitary. The liver showed a larger amount of thorium than in R2.

[2] The dust was the same as that used in the guinea pig experiments. It contained 99.5 per cent pure silica, as SiO_2.

The liver cells again showed signs of degeneration which were not as pronounced as in R1. A small amount of thorotrast was injected around the left femoral arteries. The specimen showed an absorption of thorium in the periarterial lymphatics.

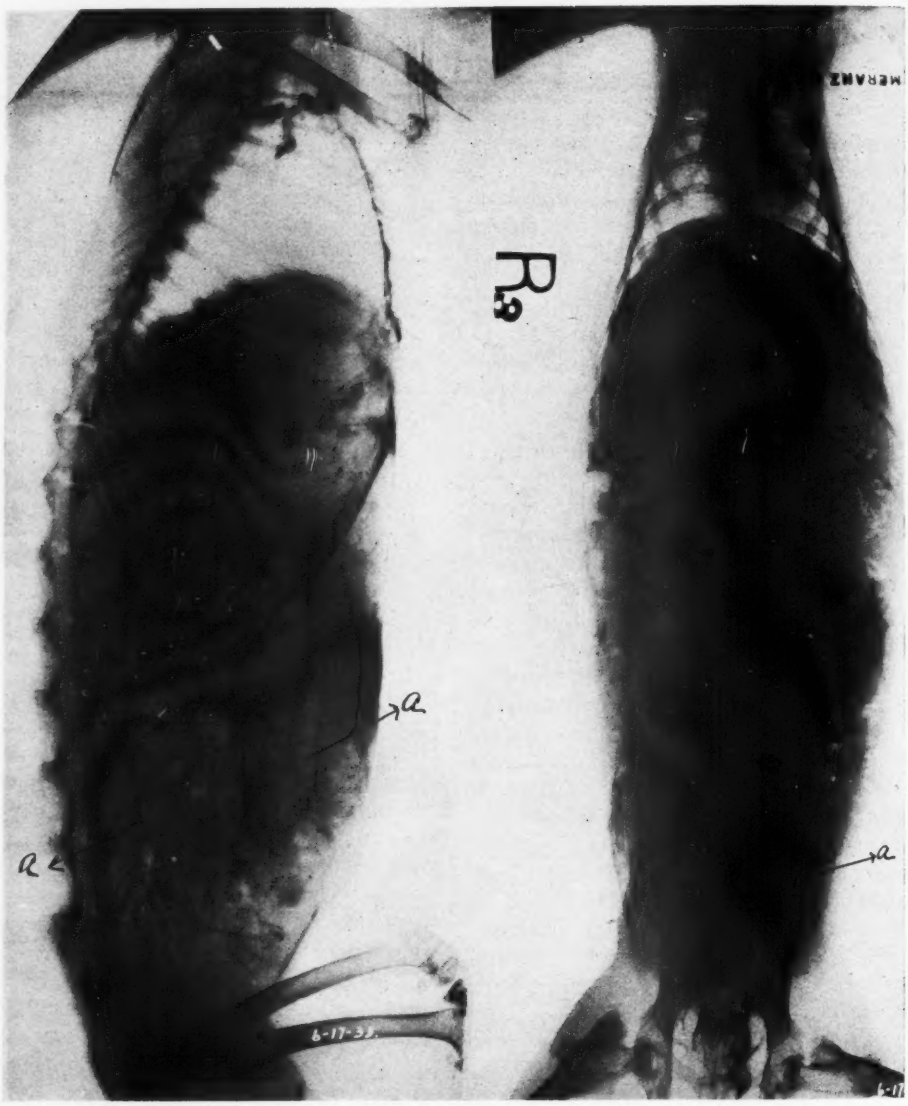

Fig. 6. Experiment III, 3 months after intraperitoneal injection of thorotrast and pure silica combined: (*a*) peritoneal and mesenterial lymphatics (compare with Figure 4 and note the small amount of thorium in the abdominal cavity); the rest is the same as in Figure 4.

COMMENT

One can readily see that the thorium injected intravenously is taken up by the reticulo-endothelial cells in the liver, spleen, and bone marrow. This gives us the opportunity of visualization of these organs by means of x-rays. One can no-

tice that the retention of thorium in the liver and spleen varies in different animals. This was also observed by Leipert. It is difficult to explain just how this takes place, unless one assumes that the absorption of thorium in the cells is not a stable process. Possibly, the thorium particles are again thrown into the blood stream and reabsorbed. The thorium is eliminated through the lungs and the gall; none, or very little, through the kidneys. The process of elimination of thorium is a very slow one. It takes months, probably years, and it may last through the life time of the individual or animal. In our experiments (R1 and R3), the liver cells show definite signs of degeneration. It is true, considering the weight of the animal, that an overdose was used, about six times as much as was necessary for hepato-lienography.

I consider also of some significance the peculiar distribution of thorium in the liver lobules. As pointed out before, the thorium is situated near the central veins and away from the periportal fields. This speaks also for possible repeated reabsorption of the metal from the blood stream.

By means of an intraperitoneal injection of thorium, we are able to visualize the peritoneal lining and the mesenterial lymphatics in normal cases, as one can readily see in the second experiment. It also demonstrates the rate of absorption of thorium through the diaphragmatic and anterior mammary lymphatics into the blood stream. From there, the thorium was again taken up by the liver, spleen, and bone marrow. Since the bulk of thorium was retained in the mesenterial lymphatics, a smaller amount reached the liver and spleen, causing no damage and showing no signs of degeneration to the liver cells. This, I think, is important in consideration of toxicity between the intravenous and intraperitoneal injections. One can foresee the possibility of visualization of pathologic processes of peritoneal lining or intra-abdominal pathology (pancreas and retro peritoneal tumors, metastatic tumors), by means of intraperitoneal injections of small amounts of the colloidal thorium. The immediate absorption of the thorium by means of lymphatics may also be of value in the study of the tumor lymphatics in different kinds of malignancy.

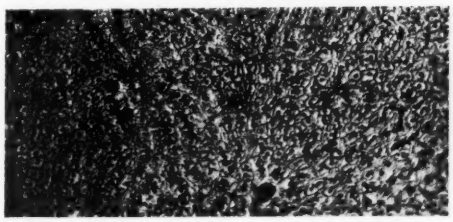

Fig. 7. Experiment III, liver, 3 months after intraperitoneal injection of thorotrast and silica combined: (*a*) pycnotic nuclei of liver cells indicating degenerative changes; (*b*) thorium granules.

The third experiment of simultaneous intraperitoneal injection of colloidal thorium and silica was performed for the purpose of studying the difference in lymphatic absorption of the two different colloidal substances. First, it could be noticed that the rate of absorption of the thorium from the peritoneal cavity was much faster when injected together with silica. Otherwise, the findings were analogous to the second experiment except for the retention of larger amounts of thorium in the spleen and liver, as in the R3, with degenerative changes in the liver cells. This brings us to a conclusion of a possibility of combining thorium with other harmless chemicals in order to speed up the rate of absorption of the metal. As a secondary result of the third experiment (R3), one can consider the production of interstitial focal pneumonitis in the lungs of the rabbit due to the retained silica particles absorbed from the peritoneal cavity (Fig. 7). This type of early interstitial pneumonia produced about three months after injection is analogous to the intravenous injection of pure silica in rats and guinea pigs reported by Martland and myself, in 1932. This experiment of combined injections also showed us the difference in the chemical affinity of the two col-

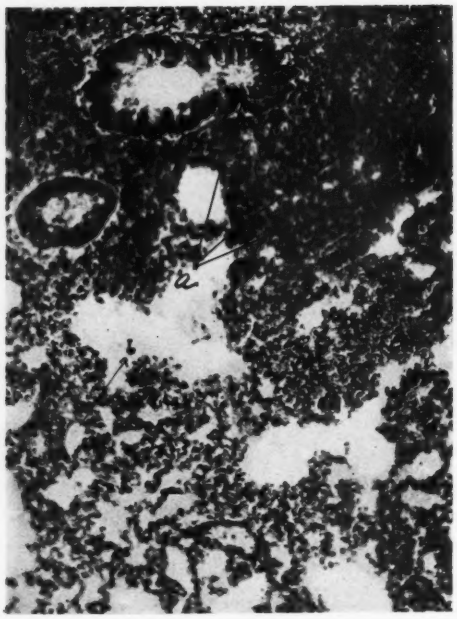

Fig. 8. Experiment III, lungs: (*a*) interstitial pneumonic type of infiltration around the large bronchus, as in early silicosis; (*b*) normal alveoli.

loidal substances; silica to the lungs, and thorium to the reticulo-endothelial system.

Notes on Radio-activity.—While our experiments were not directed toward establishing the damages of the tissues due to radio-activity, one must consider seriously the degenerative changes in the liver, in the R1 and R3. They are unquestionably the result of toxicity of the thorium partly due to an overdose, with a possible accentuation of the radio-activity by the x-ray exposures.

The radio-activity of the metal can be easily demonstrated by a simple photographic test. A piece of metal interposed between a dental film and a 12 c.c. bottle of thorotrast gave a clear image of the metal after seven days of exposure.[3] Martland showed us, in his extensive work on radioactive substances and on his human material of luminous dial workers, the importance of the fact that nothing should be done to increase the radio-activity of the

[3] The paper covering the film was interposed between the bottle containing thorium and the film.

Fig. 9. Experiment III, bone marrow: (*a*) thorium granules in the reticulo-endothelial cells of the bone marrow after intraperitoneal injection of thorotrast and silica combined.

human body. He also showed us that it will take from seven to twelve years before the latent radio-activity of thorium can be established. Until then, great care in the intravenous use of thorium is advisable.

CONCLUSIONS

1. A comparison of intravenous and intraperitoneal use of colloidal thorium was made and studied by means of serial x-ray examinations and microscopic findings.

2. In the case of intravenous injection, degenerative changes in the liver were found as a result of radio-activity.

3. The normal peritoneum, mesenterial lymphatics, and the anterior mammary lymphatics were visualized by means of an intraperitoneal injection of thorium. The rate of its absorption into the blood stream was studied. The importance of the intraperitoneal injection for recognition of abdominal pathology was stressed.

4. A combined intraperitoneal injection of thorium and silica was made. Its rate of absorption through the lymphatics was studied radiologically and microscopically.

5. As a secondary result of this combined intraperitoneal injection of thorium and

silica, a first-stage interstitial productive focal bronchopneumonia, due to silica, was produced in a rabbit three months after injection.

In conclusion, I wish to thank Dr. H. S. Martland for his kind help, which made it possible for me to prepare this paper. I also wish to express my appreciation to the Heyden Chemical Company for their help and co-operation, as well as to Mr. E. S. Rubinow, college student, for his able assistance.

31 Lincoln Park

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A GAS X-RAY TUBE FOR IRRADIATION WITH SOFT X-RAYS[1]

By H. KERSTEN, *Department of Physics, University of Cincinnati*

X-RAYS of longer wave length than 1 Å. unit, which have been more or less arbitrarily called soft, are of interest in biological experiments. A gas x-ray tube, with a fairly large window, for producing x-rays ranging from about 0.5 to about 4 Å. units and for continuous operation at such combinations of voltage (up to 50 peak K.V.) and current (up to 50 ma.) that their product is about 700 volt-amperes, is described below.

A photograph of the tube placed so that the x-rays will travel downward is shown in Figure 1. Two kinds of windows, both made of 0.045 mm. cellophane, covering openings three-quarters of an inch in diameter, are provided. Cellophane of this thickness is strong enough to withstand the air pressure and is sufficiently vacuum tight, but is damaged by heat and flying particles. The first type of window is intended to protect the cellophane by placing it about 12 cm. from the focal spot at the end of a nozzle, as shown in Figure 1 and at 7 in Figure 2. Such a window will transmit a large percentage of the L radiation of silver (about 4 Å.) and will last about half an hour when the tube is operated at 50 ma. and 15 peak K.V., or about two hours at 50 ma. and 8 peak K.V.

The second type of window, shown at the bottom of Figure 3, protects the cellophane from heat and flying particles by means of an aluminum disc placed between it and the target, and far enough away from the cellophane so that the two will not touch when the cellophane is pushed in by the air pressure. With this combination, it is possible to use a disc of aluminum which would be too thin to withstand the air pressure against the three-quarter inch opening. Such a window, with a disc of 0.045 mm. aluminum, will transmit a large percentage of the K radiation of copper (about 1.5 Å.), and will last about ten hours when the tube is operated at 10 ma. and 40 peak K.V.

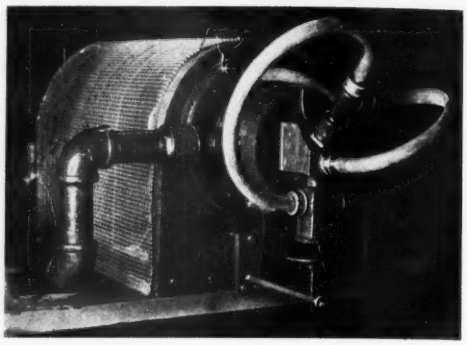

Fig. 1.

The cellophane is sealed to the nozzle, or head of the x-ray tube as the case may be, by first warming the surface to which it is to be sealed, with a Bunsen flame. After the surface is warm enough, it is "tinned" with a rather heavy layer of Picein[2] sealing wax by rubbing a warmed stick of the wax against the warmed surface. The cellophane is then pressed against this warm layer of sealing wax, and a warmed mould, having small circular concentric corrugations in its surface, pressed against the cellophane. The mould presses corrugations in the cellophane and sealing wax, concentric with the window. The cooling water keeps the sealing wax hard during the operation of the tube so that the corrugations prevent the cellophane from slipping. There are no corrugations in the surface to which the sealing wax is applied. This method of sealing on the window makes it possible to place the material to be irradiated near the window so as to permit very little loss, due to the absorption of the soft radiation by the air.

The grounded end of the tube is cooled

[1] Accepted for publication April 14, 1934.

[2] Picein is distributed by Schrader and Ehlers, 239 Fourth Ave., New York.

by tap water which enters through the hose coupling 1 (Fig. 2), passes through the tube 21 to the target 23, out of the coupling 2, through 5 and 31, and into the head of the tube through coupling 4. From this point it passes through two vertical holes

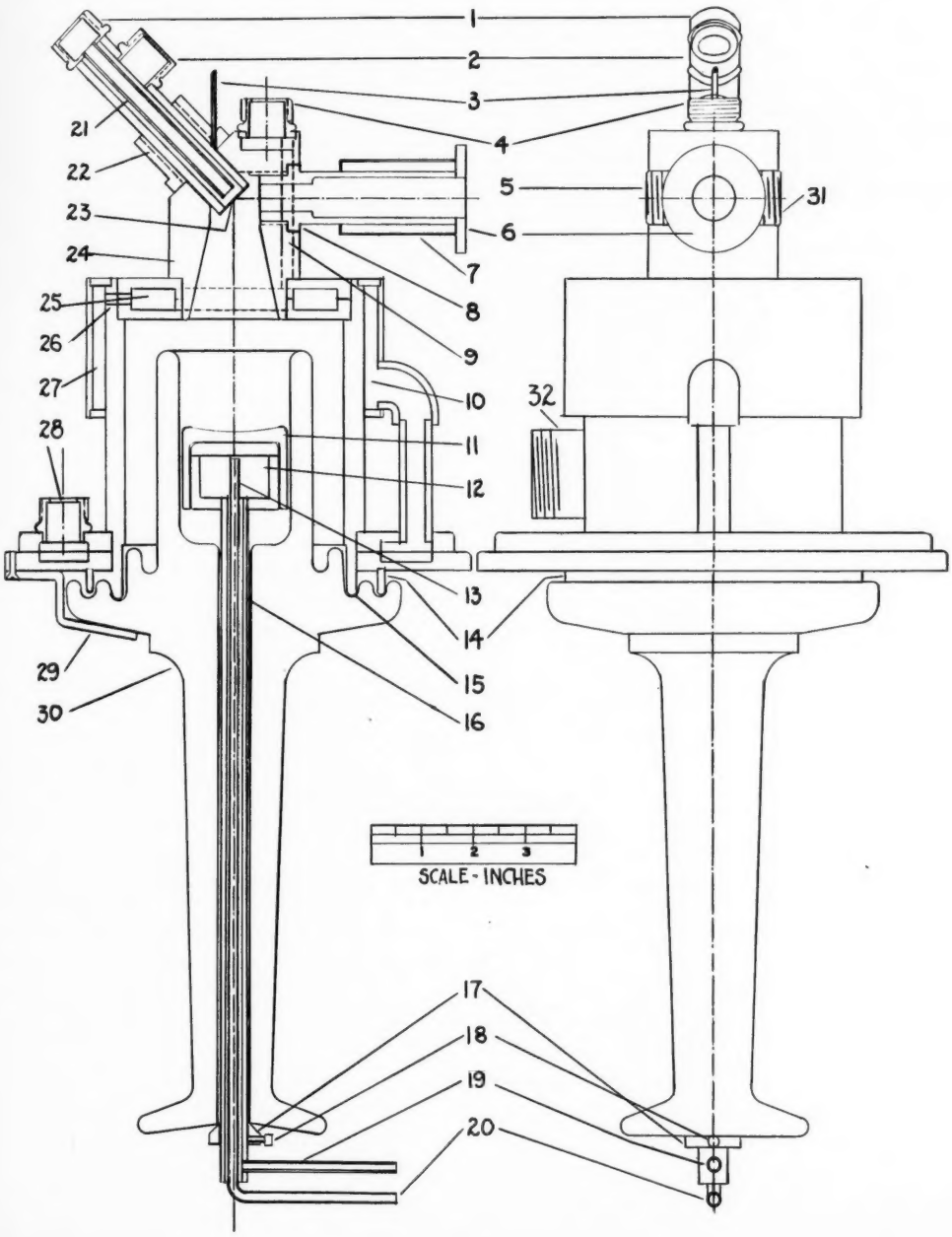

Fig. 2.

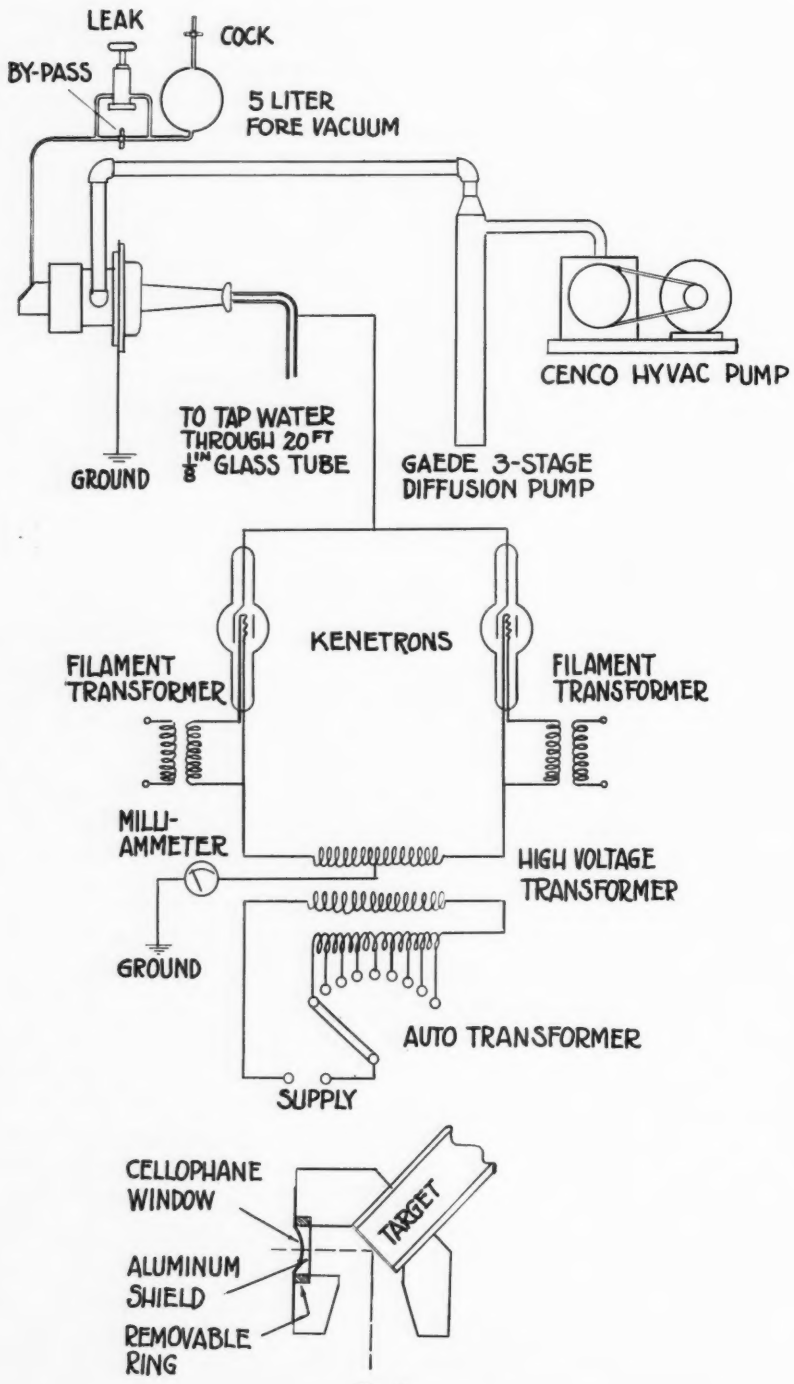
LEAK
COCK
BY-PASS
5 LITER
FORE VACUUM
CENCO HYVAC PUMP
TO TAP WATER
THROUGH 20 FT
1/8 IN GLASS TUBE
GROUND
GAEDE 3-STAGE
DIFFUSION PUMP
KENETRONS
FILAMENT
TRANSFORMER
FILAMENT
TRANSFORMER
MILLI-
AMMETER
HIGH VOLTAGE
TRANSFORMER
GROUND
AUTO TRANSFORMER
SUPPLY
CELLOPHANE
WINDOW
TARGET
ALUMINUM
SHIELD
REMOVABLE
RING

Fig. 3.

9, in the head, into the annular space 25, through the hole 26, into the jacket 27, and out through the tube 10, into the annular ring to which the insulator is attached, then out through the coupling 28. The water for part of this circuit passes through rubber hoses. The ungrounded end of the tube is cooled by tap water which passes through 20 feet of 1/8th-inch glass tube, then through 20 and 13, into the space 12, and out through tubes 16 and 19, through another 20 feet of 1/8th-inch glass tube to the drain. A small amount of current leaks away through the water to the ground.

The insulator[3] 30, is sealed at 14, with Picein sealing wax. The best method for sealing it to the metal part of the tube is to heat the latter by passing steam through the water jacket, "tin" the surfaces with sealing wax to be in contact with the insulator, and place it in a vertical position with the window end downward. Meanwhile, the insulator may be heated in an oven, the parts to be in contact with the metal "tinned" with sealing wax, and melted sealing wax poured into the outer groove of the insulator. Finally, the insulator should be pressed against the metal part of the tube, and the whole cooled by passing tap water through the water jacket. The ring and groove at 15 prevent the sealing wax from getting inside the tube. Sealing wax should also be placed around the tubes at 17. When the tube is mounted in the position shown in Figure 1, the cleat 29 takes some of the weight off the sealing wax joint.

The cathode is made of aluminum with a concave surface having a radius of curvature of about 10 centimeters. It is pressed on the copper shell 12, which provides a large amount of surface to conduct away the heat. The size of the focal spot may be changed by loosening the screw 18, and changing the position of the ring 17, to permit the cathode to move nearer to, or farther from, the target. A broad focal spot does not cause as much damage to the window as a fine one. The target and the hole at 22 are threaded to permit alignment of the focal spot with the window. The window hole is also threaded for receiving the nozzle. Both these joints are made vacuum tight with Picein.

The vacuum circuit is shown at the top of Figure 3. The tube, which is pumped out through the connection 32 (Fig. 2), is joined by means of a right-and-left-hand pipe coupling, with a one and one-quarter inch galvanized iron water pipe, the connections of which are soldered, except at the coupling and at the mercury pump. These are sealed with Picein. Since this arrangement does not permit a satisfactory liquid air trap to be inserted, some of the mercury vapor gets into the tube, amalgamates with some of the targets, and, if the voltage is high enough, gives off the L lines of mercury. For most irradiation, the extra lines do not matter. Air is permitted to leak into the tube, through the small copper tube 3 (Fig. 2), from an adjustable leak such as those which have been previously described.[4, 5, 6]

The electrical circuit[7] shown in the middle of Figure 3, makes use of two type KR-3 kenotrons, connected so as to give full-wave rectified, pulsating current.

[3] The insulator is sold by Dr. Carl Leiss, Berlin-Steglitz, Feldstrasse 10, Germany.

[4] Kersten: Rev. Sci. Inst., July, 1931, **2,** 377.

[5] Kersten and Lange: Rev. Sci. Inst., June, 1933, **4,** 332.

[6] Kersten: Rev. Sci., Inst., January, 1934, **5,** 5.

[7] The high voltage apparatus was made by the Kelley-Koett Co., Covington, Ky.

THE EXPONENTIAL LAW OF TISSUE RECOVERY APPLIED TO RADIUM AND RADON DOSAGE[1]

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IT has often been assumed that tissue recovery from radiation effects follows an exponential law. By the use of this law in the saturation technic of radiation therapy, tissue recovery is calculated for the time between treatments. When a treatment lasts for only a short time, the tissue recovery during the period of treatment is negligible; but when a treatment lasts for many hours, as many radium and radon treatments do, the tissue recovery during this period may not be negligible. In some instances, it seems possible that a better correlation between tissue effect and the dose given might be obtained if the saturation dose, which takes into account the tissue recovery during the treatment, was considered rather than the total dose.

The expression "tissue recovery from radiation effects" is indefinite because little is known about the effects of radiation on tissue. Most of the effects usually considered to be due to irradiation are probably secondary effects caused by a primary effect. The primary effect is caused by an absorption of radiation, or, since radiation is energy, by an absorption of energy; the magnitude of this primary effect must be proportional to the amount of energy absorbed. Hence, the primary effect must be an increase of the energy content of the tissue. Tissue recovery will be considered here as a process tending toward a return to the normal energy content.

The amount of energy absorbed will depend upon many factors and cannot be easily determined, but, for a specific type of radiation, it will be proportional to the amount of energy available. For any specific case it will be proper, therefore, to use a measure of the available energy as a measure of the primary effect. When treatments are given with radium or radon applicators, the strength of the applicator, in mg. of radium or mc. of radon, is a measure of the available energy. The usual notation of dosage in mg.-hr. or mc.-hr. can serve as a measure of the magnitude of the primary effect produced in the tissue, and also it can serve as a measure of the magnitude of the primary effect remaining in the tissue at any future time.

The fraction of the radiation effect that recovers in unit time is believed to vary with the quality of radiation used. This fraction, which can be called the "tissue recovery constant" and which can be calculated from data given by Weatherwax (2), is 0.044 each day for radiation filtered through 1 mm. of platinum, and 0.035 each day for radiation filtered through 2 mm. of platinum. The value of the recovery constant used in computing the data presented here is 0.05 each day, which is assumed to be approximately correct for radiation filtered through 0.5 mm. of gold or platinum. This value is chosen rather than one of the values given by Weatherwax because the data presented here are meant to apply primarily to treatments given with gold seed implants or with radium or radon needles, most of which have a filtration of 0.3 mm. to 0.5 mm. of gold or platinum.

THEORY

According to the exponential law of tissue recovery, the rate of tissue recovery is proportional to the amount of effect present. If E, expressed in mg.-hr. or mc.-hr., represents the magnitude of the effect, the excess energy content, at any time, the rate of decrease of E may be expressed mathematically by the differential equation

[1] Accepted for publication April 16, 1934.

$$\frac{dE}{dt} = -\mu E, \quad \text{(tissue recovery)} \qquad (1)$$

where the expression dE/dt is the rate of decrease of E with respect to time, μ is the tissue recovery constant, and the minus sign indicates that the value of E is decreasing. The solution of this differential equation is

$$E_t = E_0 e^{-\mu t} \quad \text{(tissue recovery)} \qquad (2)$$

where E_t is the value of E at the end of time t, E_0 is the value of E at the time $t = 0$, and e is the base of the natural logarithms.

When treatments are given with radium applicators, the rate at which the tissue receives energy is constant. The total amount of energy, which may be absorbed by the tissue during any period of time, may be expressed as the product of the strength of the applicator and the time during which it is applied: this is a measure of the maximum possible effect which may be produced in the tissue. This maximum possible effect, E, may be expressed mathematically by the equation

$$E = St \text{ (for radium)} \qquad (3)$$

where S is the strength of the applicator in mg., and t is the time in hours for which the applicator is applied. The rate, dE/dt at which energy is delivered, is found by differentiating the above equation with respect to time, and is

$$\frac{dE}{dt} = S \text{ (for radium)} \qquad (4)$$

However, as soon as the tissue begins to absorb energy, the recovery processes commence operating. The rate at which the excess energy content of the tissue is changing during the application of a radium applicator is equal to the difference between the rate at which energy is absorbed by the tissue, as expressed by Equation 4, and the rate at which the tissue recovers, as expressed by Equation 1. Therefore, the true rate, dE/dt, at which the excess energy content of the tissue is changing is

TABLE I

Values of doses delivered by a 1 mg. tube of radium and a radon tube of initial strength of 1 mc.

Days	Mg.-hr.		Mc.-hr.	
	Total dose	Saturation dose	Total dose	Saturation dose
1	24	23.4	22.0	21.4
2	48	45.7	40.3	38.3
3	72	66.8	55.7	51.4
4	96	87.0	68.5	61.4
5	120	106.2	79.2	68.8
6	144	124.4	88.1	74.2
7	168	141.8	95.6	77.8
8	192	158.2	101.8	80.0
9	216	174.0	107.0	81.3
10	240	188.8	111.3	81.5
11	264	202.8	115.0	81.2
12	288	216.4	118.0	80.2
13	312	229.2	120.5	78.6
14	336	241.4	122.6	77.0
15	360	253.0	124.4	74.8
16	384	264.4	125.9	72.6
17	408	275.0	127.1	70.3
18	432	284.6	128.1	67.8
19	456	294.4	129.0	65.5
20	480	303.8	129.7	63.0

$$\frac{dE}{dt} = S - \mu E \text{ (during application of radium)} \qquad (5)$$

The solution of the differential Equation 5 is

$$E_t = \frac{S}{\mu}(1 - e^{-\mu t}) \text{ (during application of radium)} \qquad (6)$$

in which E_t is the excess energy content at any time, t after the time when E_t and t were zero.

In Column 3 of Table I are given the results obtained by substituting in Equation 6 a value of 1 mg. for S and a value of 0.05 each day for μ. These results are shown graphically by Curve A of Figure 1. As the value of E_t increases, the rate of loss of energy due to recovery increases and eventually becomes equal to the rate at which energy is being delivered to the tissue. Theoretically, this state of equilibrium would not be reached until the end of an infinite length of time, when $e^{-\mu t}$ is equal to zero. If the state of equilibrium were reached, E_t would be equal to S/μ; on the other hand, if the excess energy content of the tissue is equal to E_t, this

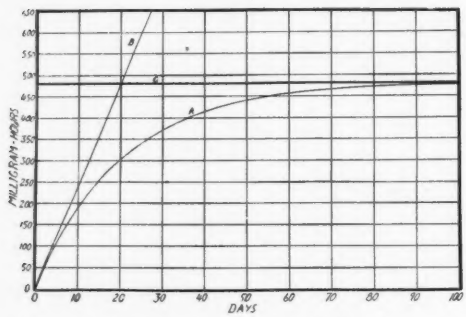

Fig. 1. Doses from a 1 mg. tube of radium: *A*, saturation dose; *B*, total dose; *G*, saturation dose that can be maintained, or maximum saturation dose that can be delivered.

excess energy content could be maintained with an applicator of strength such that

$$S = \mu E_t \text{ (radium applicator strength)} \quad (7)$$

When a radon applicator is used, the rate at which energy may be absorbed by the tissue is not constant because the strength of the applicator is continuously decreasing. The maximum possible amount of energy, E, expressed in mc.-hr., which may be absorbed by the tissue during a period of t hours can be found from the expression

$$E = \frac{S_o - S_t}{\lambda} \text{ (for radon)} \quad (8)$$

where S_o is the strength of the applicator at the beginning, and S_t is the strength at the end of the period of time t, and λ is the radio-active constant for radon (0.007506 each hour). The value of S_t can be found from the value of S_o from the equation for the decay of radon,

$$S_t = S_o e^{-\lambda t} \text{ (radon decay)} \quad (9)$$

Substituting the value of S_t from Equation 9 in Equation 8,

$$E = \frac{S_o - S_o e^{-\lambda t}}{},$$

or

$$E = \frac{S_o}{\lambda}(1 - e^{-\lambda t}) \text{ (for radon)} \quad (10)$$

The rate, dE/dt, at which energy is delivered to the tissue can be found by differentiating Equation 10 with respect to time,

$$\frac{dE}{dt} = S_o e^{-\lambda t} \text{ (for radon)}. \quad (11)$$

The rate, dE/dt, at which the excess energy content of the tissue is changing during the application of a radon applicator, is equal to the difference between the rate at which energy is absorbed by the tissue, as expressed by Equation 11, and the rate at which the tissue recovers, as expressed by Equation 1;

$$\frac{dE}{dt} = S_o e^{-\lambda t} - \mu E \text{ (during application of radon} \quad (12)$$

The solution of the differential equation 12 is

$$E_t = \frac{S_o}{\lambda - \mu}(e^{-\mu t} - e^{-\lambda t}) \text{ (during application of radon)} \quad (13)$$

By substituting the same value for μ, 0.05 each day, as in Equation 6, and 1 mc. for S_o, the values shown in Column 5 of Table I were obtained. These results are shown graphically by Curve AA of Figure 2. The results obtained for a radon applicator differ greatly from the results obtained for a radium applicator (A of Figure 1) because, after a few days, the strength of the radon applicator becomes very small, and the rate of recovery becomes greater than the rate at which energy is delivered to the tissue. A maximum value for E_t is reached about the tenth day, and after about the fortieth day the rate at which energy is absorbed becomes negligible, and the rate of decrease of E very nearly satisfies Equation 1.

The value of t when E_t is a maximum can be found mathematically by differentiating Equation 13 with respect to time, equating the result to zero, and solving for t. The result of this procedure is

$$t_{max} = \frac{1}{\lambda - \mu} \log_e \left(\frac{\lambda}{\mu}\right),$$

or, changed to common logarithms, this equation becomes

$$t_{max} = \frac{2.303}{\lambda - \mu} log_{10} \left(\frac{\lambda}{\mu}\right) \quad \text{(for radon applicator)} \quad (14)$$

Substituting, in equation 14, the same values for the constants as before, the value of t_{max} is found to be 9.85 days, and the value of E_t, from Equation 13, at that time will be 81.5 mc.-hr. when S_o is 1 millicurie.

The data presented here have been computed for an applicator strength of 1 mg. of radium, and an applicator of initial strength of 1 mc. of radon. The values of E_t, or what might be called the saturation dose at any time, for applicators of other strengths can be found by multiplying the proper value of E_t by the strength of the radium applicator or the initial strength of the radon applicator.

DISCUSSION

Very little is known about the effects of radiation on tissue and the recovery of tissue from these effects. It is known that some of the effects may appear several months after irradiation and that after comparatively intense irradiation the tissue may never recover. It is known also that long-repeated small doses will eventually produce effects that, according to the exponential law of recovery, should never be produced. Yet it is known that some recovery or return toward normal does take place. It is very logical to assume that the primary effect of radiation, which must be an increase in the energy content of the cells, takes place only during the period of irradiation, and that recovery processes are in action at all times after irradiation is started. That recovery processes are effective is indicated by the fact that the total dose needed to produce a desired effect, such as an erythema of the skin, is greater if given in small quantities over a period of several days than if given at a single time. The fact that it is possible, by means of the exponential law of recovery, to determine the amount of radiation which should be given over varying periods of time to produce such a desired effect is evidence that the exponential law of recovery does describe processes at work in the tissue. Therefore, it may be assumed that the exponential law of recovery approximately describes some of the processes taking place in the tissue after irradiation and may be used safely within certain limits. However, since it does not describe accurately all of the processes set in motion by irradiation, it must be used with caution.

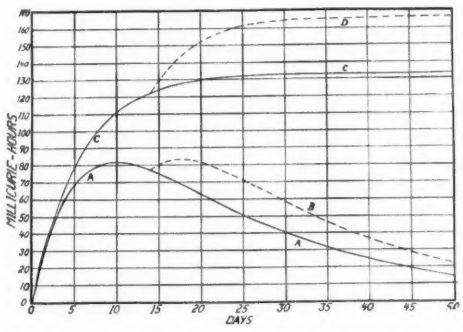

Fig. 2. Doses from radon tubes: AA, saturation dose, and CC, total dose, for tube of initial strength of 1 mc.; AB, saturation dose, and CD, total dose, for tube of initial strength of 1 mc., to which is added a tube of 0.25 mc. on the fourteenth day.

The values of μ, the recovery constant, that are ordinarily used depend only on the quality of the radiation. This variation of μ might be used as evidence in favor of the theory that the effectiveness of radiation in producing various tissue reactions varies with the quality of radiation. However, the value of μ undoubtedly varies also because of many other factors, such as type of tissue, the part of the body in which the tissue is situated, the blood and lymph supply to the tissue, and the volume of tissue irradiated. Until the variation of μ due to other factors is known, it is not possible to determine how much of the variation due to radiation quality is actual or only apparent, and until more is known about the effect of all factors on the value of μ, full use cannot be made of the exponential law of recovery.

APPLICATIONS

In order that the technic of radium or radon therapy may correspond approximately to the saturation technic used in roentgentherapy, the strengths of the applicators should be such that the desired maximum saturation dose will be delivered in from 10 to 14 days. The necessary applicator strength may be determined by dividing the value of the desired saturation dose by the value of the saturation dose delivered by a 1 mg. or 1 mc. applicator during the desired time. The strength of a radium applicator which will maintain this saturation dose can be calculated from Equation 7. It is not possible to maintain a constant saturation dose with radon applicators, but it is possible to maintain a saturation dose within a few per cent of a desired value for a considerable length of time. Curve AB of Figure 2 has been drawn from data calculated on the assumption that the strength of an applicator is increased on the fourteenth day by an amount equal to one-fourth the original strength of the applicator. The Curve AB shows that the saturation dose reaches a maximum value about the tenth day and remains within 5 per cent of this value until the twenty-third day, and Curve CD shows that the total dose reaches a value of about twice the maximum saturation dose. When treatments are given with gold seed implants, it might be feasible to make a second implantation of weak seeds two weeks after the first implantation.

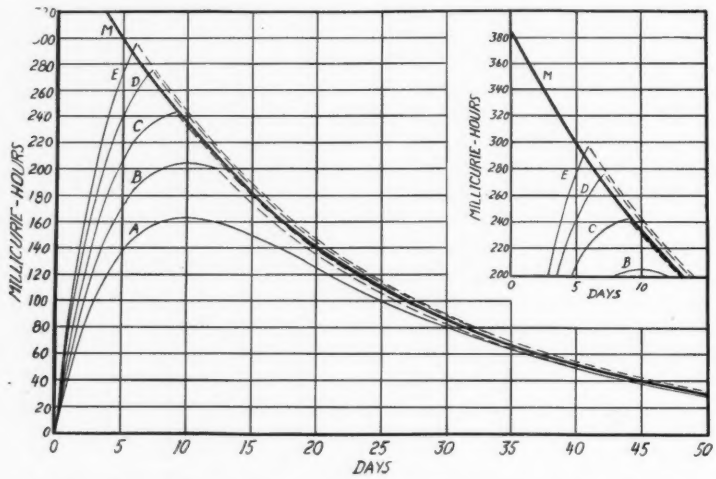

Fig. 3. Saturation doses from: A, 2 mc. tube applied permanently; B, 2.5 mc. tube applied for 12.3 days; C, 3 mc. for 9 days; D, 3.5 mc. for 7.3 days; E, 4 mc. for 6 days. Saturation doses remaining in tissue after removal of tubes are represented by broken lines. M, saturation dose remaining in tissue due to a theoretical dose delivered in a very short time when other tubes were applied.

When radium or radon treatments are given within periods of a few hours (generally by means of external applicators), the difference between the total dose and the saturation dose is small; but, when treatments are given over a period of more than a day (generally by means of internal applicators), the difference between the total dose and the saturation dose may be very great. It is known that a dose given with weak tubes may not produce the same effects as an equal dose given with strong tubes. Better correlation between effects produced and doses given might be obtained if the saturation dose were used instead of the total dose. It may be that

to produce some desired tissue effects it is necessary to give an amount of radiation which will produce a definite excess energy content in the tissue at a much later period.

It is known that some effects may be produced with total doses which are smaller when given with weak applicators than when given with strong applicators. Quimby (1) has presented data which give the time of application for radon tubes of different strengths in order to produce similar results. One set of this data states that 2 mc. applied permanently is equivalent to 2.5 mc. applied for 12.3 days, or 3 mc. for 9 days, or 3.5 mc. for 7.3 days, or 4 mc. for 6 days. By the application of the exponential law of tissue recovery to determine the saturation doses given to the tissue and remaining in the tissue after removal of these tubes, data for constructing the curves in Figure 3 were obtained. These curves show that the saturation dose in the tissue after two or three weeks after the tubes were applied is approximately the same regardless of which combination of tube strength and time was used. The data for Curve M of Figure 3 was computed, by the application of the exponential law to a value of a dose given in a very short time at the time the other doses were started, so that Curve M would approximately coincide with the other curves after the tubes had been removed. The Master Curve M, therefore, represents the saturation dose which should remain in the tissue at any time after the removal of the tubes so as to have an effect produced in the tissue similar to that which would be produced by any of the above combinations of tube strengths and times. Master curves, of course, would have to be determined for reactions desired and for the various types of applicators to be used; but, if the dose which would produce the desired reaction for one strength of an applicator were known, the master curve for that applicator and reaction could be computed.

The length of time an applicator should be applied, in order that the curve representing the saturation dose delivered would intersect the master curve, can be determined mathematically. If M represents the value of the master curve at time O (385 mc.-hr. or 16.04 millicurie-days for the data presented here), its saturation value, E_t, at any future time t can be determined from Equation 2 by substituting M for E_o;

$$E_t = Me^{-\mu t} \text{ (Master Curve)} \qquad (15)$$

The value of t desired is such that E_t from Equation 15 will be equal to E_t from Equation 6 (if a radium applicator is used), and may be found by equating the right-hand members of these two equations to each other and solving for t;

$$\frac{S}{\mu}(1 - e^{-\mu t}) = Me^{-\mu t} \qquad (16)$$

hence,

$$t = \frac{1}{\mu} \log_e \left(\frac{\mu M + S}{S}\right),$$

and changing to common logarithms,

$$t = \frac{2.303}{\mu} \log_{10} \left(\frac{\mu M + S}{S}\right) \text{ (for radium applicator)} \qquad (17)$$

Similarly, by equating the right-hand members of Equations 15 and 13 to each other and solving for t, the time for a radon applicator can be found;

$$\frac{S_o}{\lambda - \mu} (e^{-\mu t} - e^{-\lambda t}) = Me^{-\mu t}, \qquad (18)$$

hence,

$$t = \frac{1}{\lambda - \mu} \log_e \left(\frac{S_o}{S_o - (\lambda - \mu)M}\right),$$

and changing to common logarithms,

$$t = \frac{2.303}{\lambda - \mu} \log_{10} \left(\frac{S_o}{S_o - (\lambda - \mu)M}\right) \text{ (for radon applicator)} \qquad (19)$$

In Table II is given a summary of the differences between values taken or computed from Quimby's data and the theoretical values computed as described above. In only one instance does the theoretical

value differ from Quimby's value by more than 5 per cent. The one exception is that the value for the length of time which the 2.5 mc. tube should be applied differs by 12.2 per cent. This difference is not of great significance because the difference in the length of time of application produces only a small change in either the saturation dose or total dose delivered. These differences between Quimby's data and the theoretical values are no greater than the variation in dosage used in practice.

SUMMARY

Equations are presented for applying the exponential law of tissue recovery from irradiation effects to radium and radon dosage. Data which are presented and which apply to applicators of unit strength are computed from these equations by substituting a value of the recovery constant which is assumed to be correct for radiation filtered through 0.5 mm. of gold or platinum.

A technic, which will approximately correspond to the saturation technic used in roentgentherapy, is suggested for giving long radium and radon treatments.

A method is given for computing the necessary length of time of application, for radium and radon applicators of different strengths, to produce the same tissue reactions. The results obtained suggest that an important factor in dosage may be to give an amount of radiation which will produce a definite saturation dose in the tissue at a definite time after irradiation is begun.

TABLE II

Values from or calculated from Quimby's data as compared with theoretical values for tubes of same strengths. A 2-mc. tube applied permanently, a fifth condition in Quimby's data, theoretically should be 2.08 mc., a difference of 4 per cent.

Quimby's data for equal effects	2.5 mc. for 12.3 days	3 mc. for 9 days	3.5 mc. for 7.3 days	4 mc. for 6 days
Theoretical time	13.8 days	9.1 days	7.0 days	5.7 days
Difference in times	12.2%	1.1%	4.1%	5.0%
Saturation dose in Quimby's time	199 mc.-hr.	243.9 mc.-hr.	275 mc.-hr.	297 mc.-hr.
Saturation dose in theoretical time	194 mc.-hr.	244.2 mc.-hr.	272 mc.-hr.	291 mc.-hr.
Difference in saturation doses	2.5%	0.1%	1.1%	2.0%
Total dose in Quimby's time	297 mc.-hr.	321 mc.-hr.	341 mc.-hr.	352 mc.-hr.
Total dose in theoretical time	306 mc.-hr.	322 mc.-hr.	334 mc.-hr.	342 mc.-hr.
Difference in total doses	3.0%	0.3%	2.1%	2.8%
Difference between tissue saturation dose curve after tubes are removed and M curve	4.2%	0.7%	3.0%	4.1%

The use of a master curve for calculating dosage would probably be applicable for only limited variations of intensity and time. Since this method of calculating dosage is derived from the application of the exponential law of tissue recovery, it would be limited by how accurately this law describes conditions following irradiation. The application of the exponential law of tissue recovery to data presented by Quimby indicates that some reactions which follow irradiation depend on the giving of an amount of radiation in such a length of time that it will produce a definite saturation effect in the tissue at a definite time after the irradiation is begun. Within what limits the strength of the applicator and the time of application can be varied must be determined clinically.

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X-RAY THERAPY OF CARCINOMA OF THE LIP AND SKIN[1]

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THE Brooklyn Cancer Institute, a unit in the Department of Hospitals of New York City, cares for patients received from other hospitals or referred by its own staff of physicians. The hospital beds at our Institute are limited to the care of those cancer patients requiring urgent surgical or radium therapy. Chronic cases are sent to the Welfare Island Custodial Cancer Hospital. Due to the present necessity for economy and because our bed service is limited, we have found x-ray therapy the most efficient method of treating these ambulatory cases. In many instances such treatment is given with radium emanation.

Generally speaking, the radiosensitivity of any cell, including the tumor cell, ies in direct relationship to its nuclear or chromatin substance. The usual basal-cell growth is rich in chromatin substance, and, being on the surface, an exact dose can be given without fear of injury to overlying structures, while if a non-penetrating or long wave length x-ray beam is used, damage to deep structures may be avoided.

The relative penetration of the x-ray into tissues has been carefully worked out by physicists and roentgenologists; for instance, the estimation of the half value layer in aluminium by William H. Meyer (1) and the penetration of x-ray beams of different voltages as measured in a water phantom by J. L. Weatherwax (2).

Measurement of the biologic reaction in absolute roentgens (3) showed a variation with unfiltered rays of longer wave length from 400 r, increasing with harder filtered rays to 700 r, as marking a threshold erythema, without backscattering. This has led to a most accurate estimation of dosage to the surface plus a good estimation of the depth in tissues.

In spite of these accurate physical and biologic comparisons, it has been demonstrated definitely that much more than one surface erythema dose is necessary to produce a normal erythema to a lesion 2 cm. or less in diameter. This increased tolerance is carried up the scale in larger doses which would normally give vesiculation and total destruction, a knowledge of which has been taken advantage of by F. Liberson (4), who treated deeper lesions with increased doses of x-radiation without injury to the overlying skin.

J. M. Martin (5) compared the results following surgery and his own results in radiation in lip and mouth cases, reporting a large percentage of five-year cures.

B. P. Widmann (6) demonstrated how the underlying structures will tolerate very large doses to the surface, as high as 35 skin erythemas in a single case. This irradiation was delivered in divided doses, being given over relatively large areas.

The present report covers a group of cases composed of all types of epitheliomas of the skin and lip. All these cases received one massive dose either at one time or in two parts on consecutive days, 4,500 r units, or the equivalent of ten threshold skin erythemas, being delivered to the skin area, which was carefully blocked by lead rubber to within 0.5 cm. of the edge. On all superficial lesions the factors used were the equivalent of a $6^1/_2$-in. point gap, or 100 peak kilovolts, 5 milliamperes, filter 0.5 cm. of wood, estimated to act as a filter of less than 0.5 mm. of aluminum, the focal skin distance being 50 centimeters. Since we feel that the overlying cancer cells are acting as a filter, protecting the deeper structures, no cauterization or curettement of the lesion is done. It is surprising how quickly the average

[1] Read before the Radiological Society of North America at the Eighteenth Annual Meeting at Atlantic City, Nov. 28–Dec. 1, 1932.

lesion starts filling in after such radical therapy, with little or no deformity. The scar is soft and, except in very large lesions, treatment. A sluggish ulcer, remaining in a portion of the scar, is sometimes given a small dose of from one-fourth to

Fig. 1-*A*. Epidermoid cancer of the lip.

Fig. 1-*B*. Same case after treatment.

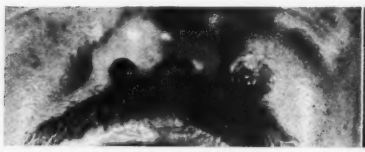

Fig. 2-*A*. Basal-cell epithelioma of the cheek.

Fig. 2-*B*. Same case, after treatment.

no telangiectatic degeneration of the small blood vessels occur. As an illustration, one female patient of advanced age had a basal-cell lesion measuring 4 inches in its greater diameter, involving one side of the neck and extending up into the scalp behind the ear. It was treated by different types of radiation and coagulation, all to no avail. With the application of the above-described x-radiation, the lesion healed entirely, without skin graft or other effort, leaving only a few small telangiectatic areas in a pale soft scar. This case has remained healed for over two years.

In one case only was a persistent denudation present. This was a large sarcoma of the soft tissues of the thigh, which had been operated upon twice. Later this patient was treated at another hospital and subsequent biopsies showed no evidence of malignant cells.

For deeper lesions, a similar dose is employed, using a $9^1/_2$-in. point gap or 132 peak kilovolts, filtered through 0.5 cm. of wood with 1 mm. of aluminum additional.

Few cases need more than the one erythema, depending upon its duration and clinical appearance.

We have found that lesions on the scalp are most radioresistant, especially if they are deep-seated. These are often atypical in their pathologic structures, many containing certain glandular alignment of the cells. While they not uncommonly become smaller after treatment, there remains usually a small nonhealing ulcer, biopsies of the edge of which show only scar tissue. Could these resultant ulcers be cared for by plastic surgery?

Melanotic lesions are as a rule most radioresistant and, though the local lesion may be destroyed, metastases have usually developed in other parts. These secondary lesions appear to have no relation to x-radiation of the original lesions, but have either metastasized spontaneously or as a result of previous manipulation.

The third type most resistant to this form of radiation are the squamous-cell lesions of the extremities, which often require at least twenty skin erythema doses. The danger of widespread dissemination in these cases is great. One case with a

primary squamous-celled lesion on the heel of a young woman was entirely healed after the application of 20 skin erythema

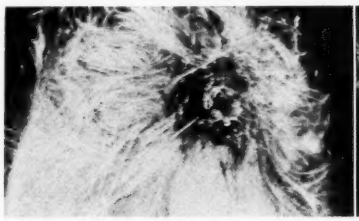

Fig. 3-*A*. Epidermoid cancer of the scalp.

Fig. 3-*B*. Same case, after treatment.

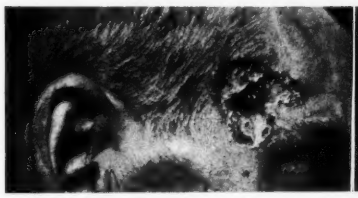

Fig. 4-*A*. Basal-cell epithelioma.

Fig. 4-*B*. Same case, after treatment.

doses. Over a year later she was admitted to another hospital where she was operated upon for an abdominal tumor, which proved to be due to large secondary retroperitoneal metastatic nodes. She was returned to our service, where she died. A careful autopsy disclosed a dissemination more general than miliary tuberculosis.

The small squamous-celled lesions of the lower lip are most responsive to this type of x-ray treatment and the prognosis is good, provided cervical glands have not developed. The technic used is a $9^1/_2$-in. gap, equivalent to 132 kilovolts, 5 milliamperes, filtered through 0.5 cm. of wood, blocking the intrinsic structures of the mouth with lead rubber. All infected teeth are removed before therapy is begun. These cases are always followed up with a course of roentgen-ray therapy to the lymphatic nodes of the neck. Infections in the mouth have at times resulted in serious necrosis and osteitis of the jaw.

Statistics.—All cases reported have positive biopsies. The youngest was a female, 19 years of age, with a basal-cell lesion on the face. The oldest was a male, 88 years of age, with a basal-cell lesion on the face.

Six lip cases with positive biopsies have been treated, three in 1931 and three in 1932; only one, treated in October, 1932, is registered as unimproved. None of these cases had cervical metastases and no metastases have developed, all having received therapy to the cervical glandular areas.

In 1930, seven basal-cell tumors were treated and two of the squamous-cell type: one patient had multiple basal-cell lesions. Four of these cases are classed as healed; three were not traced but noted as improved. One patient had a squamous-celled lesion on the sole of the foot, for which later he had his foot amputated because the lesion did not heal. He died less than one year later from metastases. One lymphosarcoma of the neck is healed and the patient shows no evidence of other lesions. One lymphosarcoma of the thigh shows persistent ulceration. Fourteen basal-cell lesions were treated in 1931,

of which ten are noted as healed; one patient died. Four cases were not traced, but noted last as improved.

Of the other pathologic groups, one squamous-cell lesion of the shoulder has remained healed without evidence of metastatic lesions. One adeno-cystic-carcinoma of the scalp is only improved, but biopsies of its edge are negative for cancer cells. One squamous-cell lesion of the arm has healed following 20 skin erythema doses, but the woman has developed metastases in the axilla. One large epidermoid carcinoma, originating in a tremendous burn scar of the back, has not been improved.

SUMMARY

1. An efficient, inexpensive method of treating large numbers of patients who apply to the usual free cancer clinic is given.

2. The *rationale* of this method is backed by physical measurements and previous clinical and radiation reports.

3. Eight to ten erythemas are given, using a practically unfiltered x-ray beam of little penetration.

4. It is important to carefully block to the lesion, and to estimate the depth of all lesions.

5. This method is not complicated by association with surgery, electrocoagulation or other treatments.

6. The results appear comparable with other acceptable forms of treatment.

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OBJECTIVE OTOLOGIC ROENTGEN STEREOSCOPY AND ITS SIGNIFICANCE FOR THE ROENTGEN DIAGNOSIS OF DISEASES OF THE MASTOID PROCESS[1]

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ENGLISH TRANSCRIPTION BY H. A. JARRE, M.D., DETROIT, MICHIGAN

ROENTGEN technical improvements in the demonstration of the temporal bone, especially its petrous portion, still are welcome as the exploration of this area, due to its complicated structure, is quite difficult. Any methods permitting of correct identification and spatial correlation of the various superimposed structural shadows deserve critical evaluation. It is presupposed in this paper that the reader is familiar with various typical projections of the temporal bone, especially those devised by Schüller, Stenvers, and Mayer; furthermore, that he is familiar with the principles of roentgenstereoscopy.[2]

The three special projections of Schüller, Stenvers, and Mayer are regarded as sufficient for satisfactory demonstration of all detail desirable. The Schüller projection furnishes a good survey of the entire pneumatic system, the course of the venous sinus, and the ala of the temporal bone; the apex of the mastoid process also may be readily differentiated. The Mayer projection demonstrates to best advantage the spaces of the middle ear, especially the attic, and the mastoid antrum, while the Stenvers projection is chosen when information is desired concerning the apex of the pyramids, the labyrinth, and the tegmen. All other projections—more than twenty have been recommended in the roentgenologic-otologic literature—may be omitted without sacrifice, when correct stereoscopic projections in the three types mentioned, are secured.

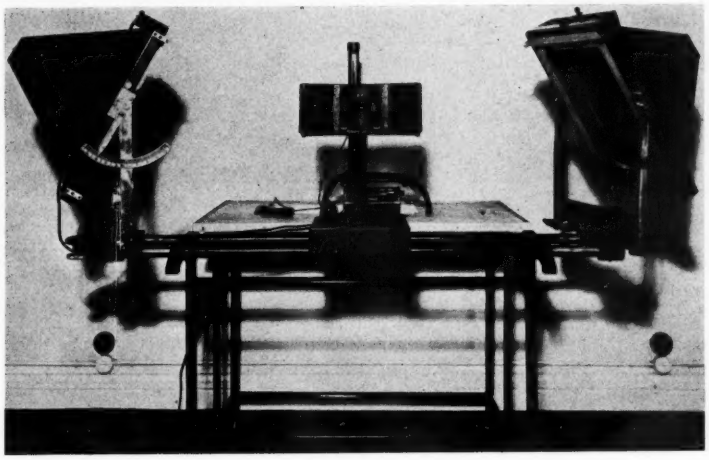

Fig. 1.

Tautomorphic roentgen stereoscopic dem-

[1] Accepted for publication July 17, 1933.

[2] See Jarre and Teschendorf, RADIOLOGY, August, 1933, **21**, 139.

onstration of the temporal bone with any of the common oblique projections has not been described previously, though, of course, stereoscopic procedures, as, for instance, inherently incorporated into the Reaves "Radiographscope" and the Hasselwander "Stereoskiagraph," point toward correct application of physical laws with such projections. As long as it is possible to reproduce conditions of projection during visual observation of stereoscopic images, all distortions due to oblique projections may be visually eliminated so that correct spatial relationship is not only perceived but may also be proven by stereoscopic measurements. Therefore, if one will record the angles of inclination, besides all other stereoscopic data; if one, furthermore, will devise a viewing apparatus, permitting of a reproduction of such angles, then correct spatial evaluation is possible.

Many of the tube stands commonly in use for roentgenography are equipped with calibration, which permits one readily to record any angle of inclination of the inciding roentgen-ray beam. Roentgen stereoscopes commonly in use have no such calibration; many of them permit of a rotation of the viewing boxes around a vertical axis in a horizontal plane, but they do not permit of an inclination of these boxes around a horizontal axis. Suspension of these viewing boxes in a fork, mounted on their usual supports, will easily accommodate for all necessities, especially when suitable calibration in the horizontal and vertical planes are incorporated (Fig. 1). Correct focussing devices on the stereoscopes and marking of the axial rays on the stereo images are essential. All projections of the temporal bone preferably are obtained with the use of a long narrow cone rather than with a Bucky diaphragm. Care must be taken that the tube shift is performed parallel to the plane of the film.

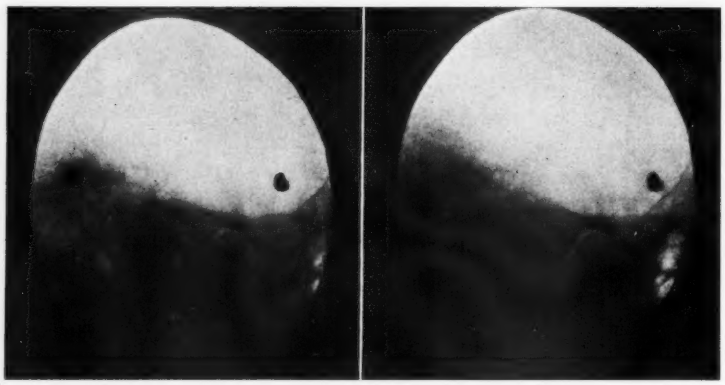

Fig. 2.

We are not unmindful of the fact that acute inflammatory disease of the mastoid process, analogous to acute infectious processes of other portions of the skeletal system, not infrequently may cause considerable difficulty and uncertainty in roentgen diagnosis. In the early stages of the disease, when diagnosis is so essential, one may often notice merely a diminution of air content of the cells of the mastoid without evident destruction of intercellular septa. An extensive bionecrotic condition of the bony trabeculæ may then surprise roentgenologists and surgeons. An exclusive, clear-cut diagnosis, or clear-cut roentgen indications for operative interference cannot be expected in all cases of early acute osteomyelitis of any portion of the temporal

bone, any more than it may be hoped for in all cases of early osteomyelitis in any other bone. History and clinical observation will have to be taken into consideration, together with, or eventually regardless of, roentgenologic appearance. The symmetrical and well pneumatized mastoid process, of course, offers better chances for roentgenologic diagnosis than the irregular mixed type of pneumatization, though stereoscopic visualization may be of material aid in the recognition of spatial relationship and differentiation of various structures.

A few illustrations and case histories may emphasize statements made. The first case cited is one of acute otitis media of three weeks' duration. Mild sagging of the posterior wall of the auditory canal was present. There was marked soreness of the entire mastoid, on palpation. Projection according to Schüller (Fig. 2) shows: Well pneumatized mastoid process, all cellular structures clouded. Only cells in the region of the sinus are aerated to a somewhat better degree. A large space overlying the sinus represents a large mastoid cell and not an area of destruction.

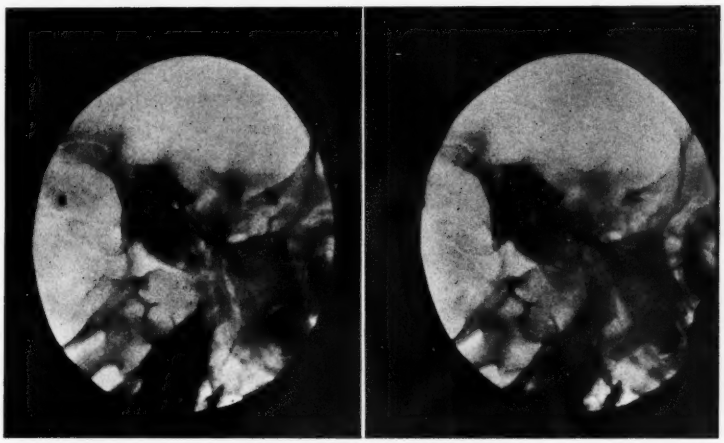

Fig. 3.

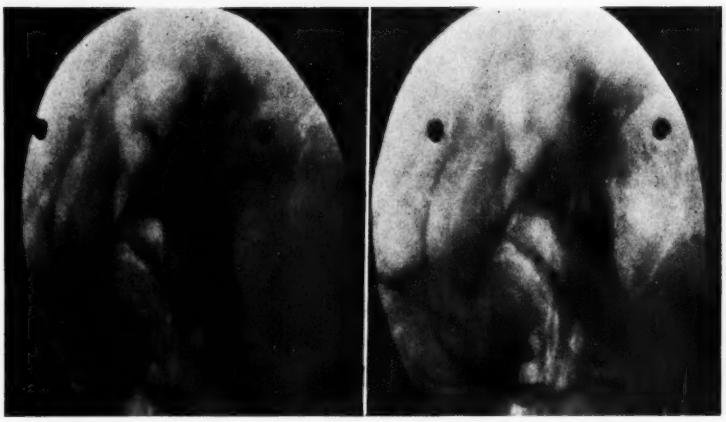

Fig. 4.

Cellular septa above the mastoid antrum and toward the angle of the petrous portion are extensively destroyed. No clear-cut osseous structure can be recognized in this region. The operative findings were: evacuated by rinsing of the ear. Projection according to Mayer (Fig. 4) shows: Rather sclerosed mastoid process; a large cavity of more than hazel-nut size may be recognized above the acoustic meatus toward the angle of the petrous bone, believed to represent the much enlarged mastoid antrum; the osseous acoustic meatus appears to be much thinned out. The diagnosis of cholesteatoma was confirmed at operation.

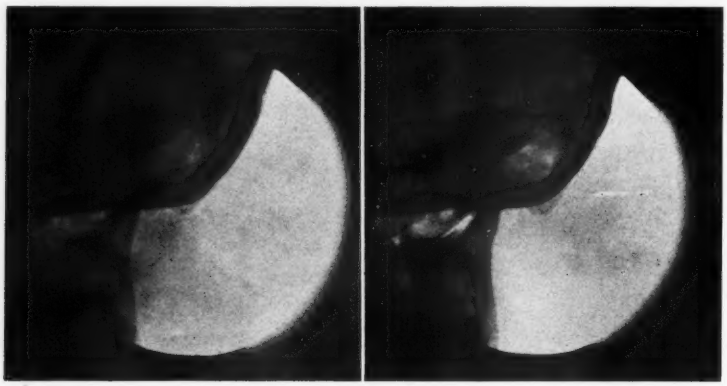

Fig 5.

All cells are filled with pus; small areas of destruction are found in the tip of the mastoid and, furthermore, between the mastoid antrum and the angle of the petrous portion; no involvement of the area surrounding the sinus.

The second case is that of a child six years old, with a running left ear of several months' duration. Projection according to Schüller (Fig. 3) shows: Small mastoid process with little pneumatization. On stereoscopic exploration one can detect a large cavity of nearly hazel-nut size, deeply situated between the acoustic meatus and the angle of the petrous bone. The mastoid antrum apparently is entirely replaced by this cavity. An additional small area of destruction is found in the region of the tip of the mastoid process. The area of destruction apparently is extending close to the sigmoid sulcus. Stereoroentgenologic observations were entirely confirmed at operation.

The third patient, H. D., 19 years old, had had a running ear since childhood, with foul secretion. There is a marginal perforation of the drum through which fetid masses from a cholesteatoma can be

The last patient whose case is cited is H. M., aged 46, who, since childhood, had had a periodically running left ear. The acoustic meatus is narrowed to a small slit by a markedly circumscribed protrusion of the upper posterior wall and, in addition, by a pedunculated polyp. Gumma was somewhat suspected. Projection according to Stenvers (Fig. 5) shows: A large cavity extending to the upper border of the pyramid, while the inner acoustic meatus and the area of the labyrinth reveal no roentgenologic changes. On account of the well demarkated delineation of the large cavity, cholesteatoma was diagnosed, which assumption was well confirmed at operation.

CONCLUSIONS

Stereoscopic exploration of the temporal bone improves diagnostic evaluation considerably. Typical projections—prefer-

ably according to Schüller, Stenvers, and Mayer—cannot be dispensed with; they are as essential for stereoscopic as for single-film demonstration of various detail. Stereoscopic images must be obtained "objectively correctly." By observation under corresponding angles, distortions due to the oblique projections may be compensated for and visually eliminated. This valuable and instructive correction of distortion cannot be regarded as a complication of the method—the angulations of the tubes for the various oblique projections are known and correct adjustment of the visualized records is, therefore, readily accomplished.

Note.—The accompanying reproduction may be viewed in nearly correct proportions if the book-stereoscope is held at such an inclination to the plane of the images that the viewing direction approximately equals that of the projections. The projection of Schüller thus entails an angle of about 120 degrees, the one of Mayer an angle of 135 degrees. This, however, does not completely reproduce the effect of tautomorphic orthostereoscopy, as is possible with a proper stereoscope and films.

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ROENTGEN FINDINGS IN SMALL STOMACH LESIONS COMPARED WITH INTRAGASTRIC PHOTOGRAPHS OF THE LIVING SUBJECT[1]

By P. E. THAL, M.D., *Chicago*

CLOSER co-operation of gastro-enterologists and surgeons with roentgenologists, and their untiring efforts to improve the technic and the diagnostic value of their findings has resulted in the recognition of gastric pathology much earlier than was possible a few years ago. To-day many small deviations from the normal shadow on the skiagram, which were overlooked in the past, are of definite diagnostic value to us.

Fig. 1. Gastro-photor apparatus.

From year to year, the percentage of negative roentgen findings in patients with positive symptoms, is becoming less and less. Much suffering and expense is spared the patient as a result of an early and accurate diagnosis, made possible through the ever-increasing efficiency of roentgenology. Yet, in spite of all of the success that has crowned our efforts, we cannot feel that we have attained perfection and are often confronted with the painful realization of the inherent limitations of roentgenography and are ever on the lookout for means to improve the value of our findings.

The permanent record furnished by the roentgenograms has played no small part in

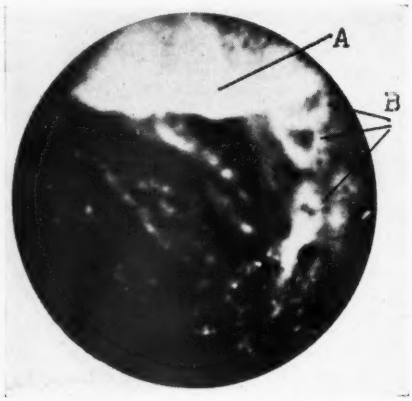

Fig. 2. An intragastric photograph of a patient with moderately acute symptoms. The roentgen examination revealed gall bladder pathology but the stomach findings were indefinite, except for showing marked spasticity near the pylorus. The photograph shows a spastic fold at *A*, and a series of small ulcers or erosions at *B*, which no doubt caused the stomach symptoms and produced the spasticity. From the appearance of this pathology, a resection was not deemed necessary. However, the stomach was explored while doing a cholecystectomy and the lesion confirmed.

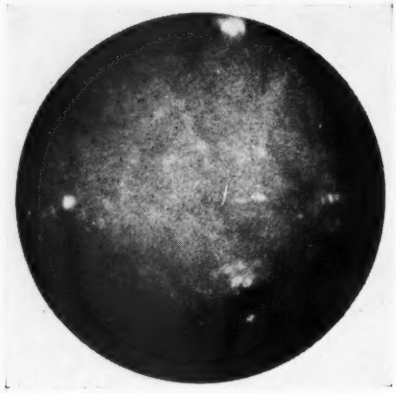

Fig. 3. A patient whose symptoms were very acute. Roentgen examination showed marked gastric irritability and rapid emptying. The photograph shows two round ulcers which not only convinced the doctor but also the patient, making proper treatment possible.

[1] Presented before the Radiological Society of North America, at St. Louis, Nov. 30–Dec. 4, 1931.

Fig. 4. A patient whose skiagrams showed a typical incisure of the greater curvature, which we have always looked at as evidence of pathology in the opposite region of the lesser curvature. The photograph shows a small but deep ulcer on the lesser curvature at *A*, and a smaller and more superficial erosion near by at *B*.

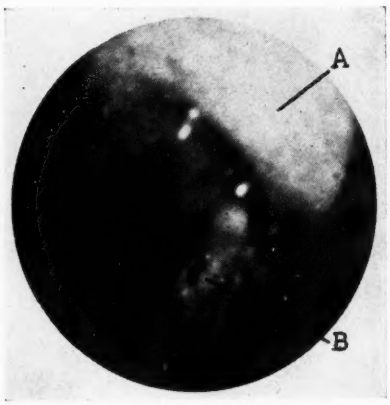

Fig. 5. A patient with moderate and indefinite gastric symptoms. Roentgen findings showed spasticity but no definite pathology was seen. The photograph shows a spastic fold at *A*, and a small round ulcer at *B*.

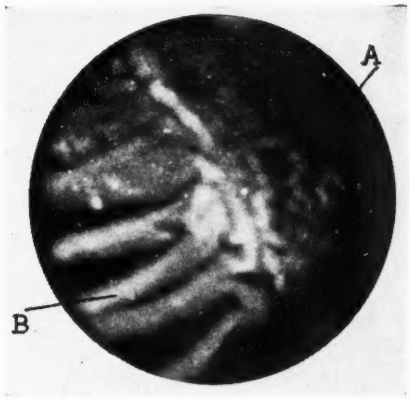

Fig. 6. An intragastric photograph of a patient who had a partial gastrectomy a few years before. A section of the scar at *A*, and the marked corrugation of the stomach wall at *B*, are readily disclosed.

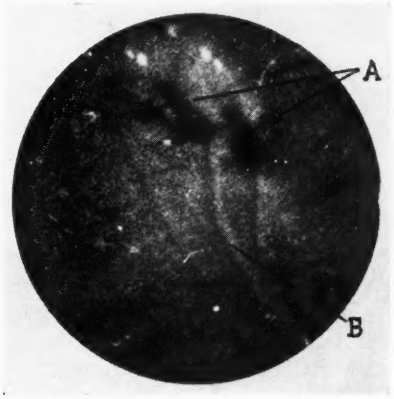

Fig. 7. A patient whose roentgen findings were quite indefinite but his symptoms were very persistent. The photograph shows two small but very deep ulcers at *A*. *B* shows the rugæ converging into the pylorus. This lesion was confirmed at operation and the patient became symptom free after a gastroenterostomy.

making roentgenology popular and dependable. The information obtained by fluoroscopy is of inestimable value but sometimes it is difficult to convey a vivid word picture of what we see to the internist.

Actual visual inspection of any part under examination has always held first place in diagnostic value. For example, many elaborate systems of roentgen examination of the urinary bladder have been devised and practised, yet what we can see through the cystoscope is invaluable.

Visualization of the gastric mucosa has been an unsatisfied desire of the gastroenterologists of all times. It is the purpose of this paper to briefly discuss the attempts made in the past to see the inside of the stomach and to show the results obtained by photographing its interior,

with the view of learning what of value can be added to our diagnostic information.

Long before the discovery of the roentgen ray, various, more or less successful, attempts were made at gastroscopy. The

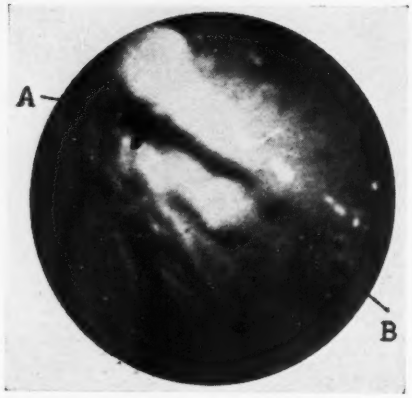

Fig. 8. At *A*, is shown the photographic appearance of a gastroenterostomy opening about 18 months after the operation. *B* shows some small erosions at one end of the opening.

difficulties encountered in this, and the limitations of its diagnostic value are many. It is a procedure of utmost discomfort and carries a much higher risk of injury to the patient than any other diagnostic instrumentation that is in use to-day. The introduction of a straight rigid instrument through the esophagus, around the base of the heart, and through the cardiac orifice of the stomach, necessitates pulling these structures out of their normal alignment. The irritation of this causes the stomach to convulsively contract. Attempts to inflate the stomach under such conditions are only partially successful. Usually, as one portion is dilated under air pressure other portions are in a state of spastic contraction. Under these conditions the stomach cannot be uniformly inflated or made to remain more or less still so that a careful inspection of its interior can be made. Because the views seen through the gastroscope are fleeting and are in focus for only a brief moment, it is difficult to get an accurate idea of the general appearance of the interior of the stomach.

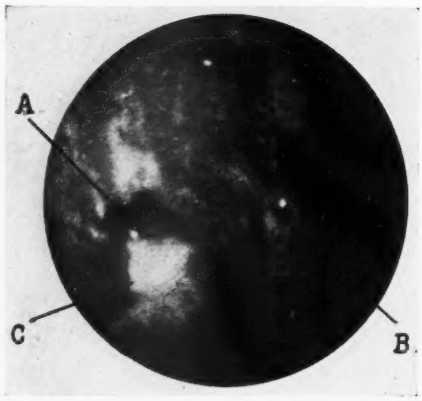

Fig. 9. A photograph of the pyloric region of a patient whose roentgen examination showed abormal spasticity in the lower part of the stomach, and a filling defect in the prepyloric region, suggesting the presence of a mass which was diagnosed as a probable carcinoma. *A* shows the pylorus in the background partially obstructed by a mass of redundant mucosa *C*. At *B* we see a small ulcer on the border of the spastic fold.

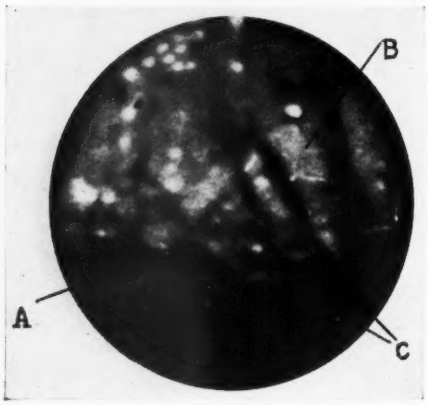

Fig. 10. A photograph of a section of the prepyloric region in a man 69 years of age, whose son was a physician. Roentgen examinations had been made at two different laboratories in other cities and a diagnosis of carcinoma was made by both, but the photographs showed a deep cicatricial deformity at *A*, spasticity and interruption of rugæ at *B*, and small ulcers at *C*. Numerous other views were made which convinced us that we were dealing with a benign condition, and proper treatment was instituted which gave complete relief. It is now three years since the treatment was given, and the patient is alive and enjoying the best of health.

The earliest attempts to photograph the interior of the stomach, of which we have any record, were made in 1885. However, the instruments were crude and unwieldy and gave no better results than those obtained by gastroscopy. These earliest cameras designed for intragastric photography were rigid tubes, equipped with a single lens, required long exposures, and covered only a small field at each exposure. The idea was to move the camera up and down and turn it in the different directions in order to secure views of the entire stomach. No patient could stand such an ordeal and it was impossible to inflate the stomach satisfactorily because of the rigidity of the instrument. Little progress was made in this field until six or seven years ago when Dr. Heilpern, of Vienna, revived the subject. He was assisted by Mr. Back, who worked out the mechanical problems. They developed a very simple and relatively efficient instrument (Fig. 1) by which they were able to obtain gratifying results.

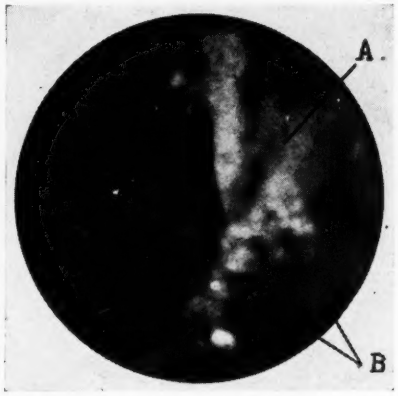

Fig. 11. A patient whose roentgen examination showed spastic folds. At *A*, we see the photographic appearance of such a fold; at *B* the ulcers, confirming the assumption based on the roentgen evidence.

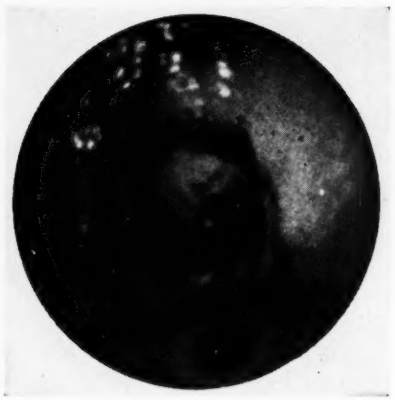

Fig. 12. A photograph of the pylorus at relatively long range. No pathology is disclosed.

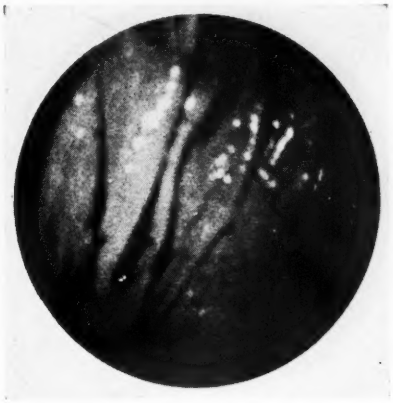

Fig. 13. A photograph of relatively normal rugæ, converging toward the pyloric region in the lower border of the picture.

As I used this instrument in the work of forming the basis of this paper, it may be well to give a brief description of it, as well as the technic of its use.

The instrument consists of two cameras, one placed above and one below an illuminating bulb. The entire assembly is small enough to be passed into the stomach with ease. Each one of these cameras has four film chambers arranged so that one film is directed toward the right, one toward the back, one toward the left, and one toward the front of the stomach. This arrangement enables us to secure eight exposures simultaneously, making two views of the lesser curvature, two of the posterior wall, two of the greater curvature, and two of the anterior wall. The camera as-

sembly is attached to the end of a small flexible tube through which the manipulating mechanism and the lighting wires pass. This tube is small and flexible enough so that it does not cause any irri-

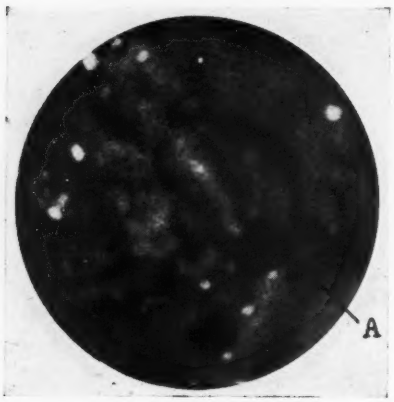

Fig. 14. Here is shown the deformity of the rugæ from cicatricial contraction surrounding a small ulcer at *A*. Roentgen findings were rather uncertain.

tation in the esophagus and readily conforms to the curvature of the cardia. This makes its use a procedure which is easy on the patient, and a complete inflation of the stomach is therefore possible.

The technic is quite simple; the patient presents himself with a fasting stomach; the small amount of fluid, usually found in the stomach, is removed with a tube. The camera is introduced into the stomach in the same manner as the passing of a lavage tube. This is done under fluoroscopic control which enables us to focus the camera on the region of principal interest and to see when the degree of inflation is proper. When all is set, the exposure is made by opening the shutter and flashing the light bulb. Now the camera is withdrawn and the films are treated like any photographic negatives.

Owing to the extremely short focal length of the camera, which makes use of the "pin-hole" principle, we have a much reduced image on the negatives. These

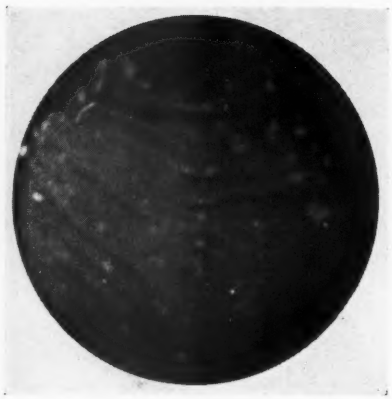

Fig. 15. A photograph of normal rugæ. The uniform angulation seen through the center is brought about by a deformity of the stomach caused by an operation.

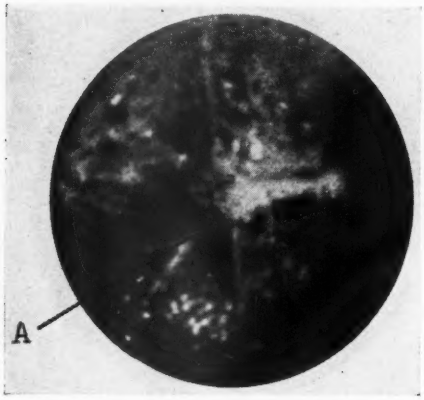

Fig. 16. Here is shown a cicatricial deformity at *A*: the roentgen examination showed a filling defect which was interpreted as an acute ulcer.

are brought back to convenient size by the use of an ordinary enlarging process as in the making of photographic prints. The entire procedure takes only a few minutes and can be run conveniently just before starting the gastro-intestinal series. By the time the roentgen series is completed, the finished photographs are ready to add what they may to our diagnosis.

Time does not permit giving detailed case histories, or the showing of all of the films made in each case, and to select just one and claim to prove any point by it

might be misleading. It is understood of course that all of the patients had the clinical symptoms which called for roentgen examination. Because you are all so familiar with the roentgen findings, I believe that it will be sufficient just to allude to them, showing you in detail the results of intragastric photography.

It is understood of course that, regardless of how perfect a photographic reproduction we could secure of the interior of the stomach, there would still be much valuable information, such as the size, general contour, position, peristaltic activity, emptying time, etc., which could only be secured by the roentgen examination.

CONCLUSIONS

Intragastric photography has consistently confirmed the indirect roentgen evidence of pathology.

(1) This was especially constant when the symptoms were of short duration.

(2) In many instances it served to clear up questionable points.

(3) It shows small and superficial lesions which escape roentgen detection.

(4) It can be carried out with ease and safety to the patient.

(5) It is at present the best means available for visualizing the gastric mucosa.

(6) When taken in conjunction with the roentgen examination, it adds valuable information to our diagnostic picture.

31 N. State St.

THE EFFECT OF ROENTGEN-RAY EXPOSURES OF THE CEREBRAL CORTEX ON THE ACTIVITY OF THE CEREBRAL HEMISPHERES

By PROF. DR. M. I. NEMENOW, *Leningrad, U. S. S. R.*

From the State Roentgenologic, Radiologic, and Cancer Institute

WHEN the effect of roentgen rays on the animal and human organism was revealed the attention of investigators was naturally directed to the nervous system, namely, the cerebral cortex. Nevertheless the numerous investigations along these lines have produced little better than negative results. At any rate, they did not succeed in establishing either histologic changes in the cerebral tissue or degenerative changes in the ganglion cells of adult animals (Sicard, Bauer, Labeau, Walter and others). Experiments carried out in connection with the exposure of new-born animals proved to be exceptions, for here a number of workers (Krukenberg, Foersterling, Nemenow, Mogilnitsky, and Podliashuk) observed a marked backwardness in the brain development of exposed animals. My studies of the effect of heavy dosage of roentgen rays on the brain of mice and guinea pigs have also mostly shown negative results.

I have often asked myself whether roentgen rays actually had no effect on nerve cells or whether the nature of the changes produced was such that we are unable to observe them by such means as are now available.

To me, the latter consideration seemed to account for the fact. Indeed, the microscope we use is but a crude instrument if we consider the elements of which the cell is composed, *i.e.*, molecules and atoms. On the other hand, we observe a series of mental diseases which are considered to be functional disturbances of the cerebral activity. These include, for instance, hysteroneurasthenia, circular insanity, etc., and are regarded as functional psychoses merely because their anatomic substrate remains unknown.

The question arises: can the conception of a function without an anatomic substrate be in harmony with our materialistic outlook?

Any function, either normal or pathologic, has a definite corresponding physicochemical substrate, a certain morphology, and a change in the function necessarily depends on the change of the substrate.

Having accepted this hypothesis, which should be essential to every investigator in the field of natural sciences who is possessed of a materialistic outlook, I came to the conclusion that, if we are unable to establish subtle changes in the structure and physicochemical condition of the cells, we still can attempt to establish the changes in the function of these cells. If we are unable to establish the histologic changes caused by roentgen rays in the ganglion cells of the cerebral cortex, is it not possible to establish changes in the function of these cells subsequent to the exposure of the brain to roentgen rays?

It is to the fundamental work of I. P. Pavlov that we are indebted for the method of investigating the activity of the hemispheres of the cerebral cortex. Pavlov's method consists in studying the conditioned reflexes. The method is so accurate, subtle, and refined that I am sure if there are any changes occurring in the function of the cerebral cortex due to the exposure of the brain to roentgen rays, they will be revealed by the method of conditioned reflexes.

Only in the Autumn of 1927 did I at last succeed in carrying out my intention. I. P. Pavlov kindly met my desires halfway and permitted me to use both his laboratory and his trained experimental animals for my work. I shall now take the liberty of describing in brief the es-

sence of the method of studying conditioned reflexes for the benefit of such of my comrades as may not yet be familiar with it.

By the term reflex, we mean the generally known physiologic process which consists of: (1) the reception of external irritation by our senses; (2) the transformation of the energy of the stimuli into nervous energy which is conveyed by the nerves to the centers of the cerebral cortex and the spinal cord; (3) the transmission of nervous impulses from these centers to this or the other organ, either motor or secretory.

Thus, for instance, food introduced into the animal's mouth cavity transmits the irritation from the nerve plates of the mucus along nerve stems to the center of salivation, located in the medulla oblongata, and from there the nervous impulses are conveyed to the secretory nerves of the salivary glands. This results in salivation (unconditioned reflex, conditioned salivation).

However, the reflex occurs not alone when food is introduced. The mere sight of food, the movements of the person making it ready, its smell and all that refers to food serve to produce salivation in a greater or lesser degree. In this case the reflex is transferred by the retina, the nerve plates in the mucosa of the nose, the external auditory apparatus (the sound of the utensils being moved, etc.).

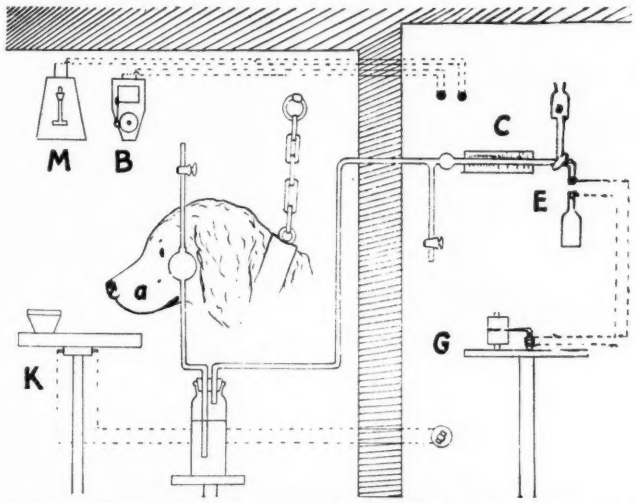

Fig. 1. Scheme of chamber with a dog in it during the experiment: (*a*) Rubber bulb attached to the fistula; (*D*) scale; (*E*) point of closing the circuit; (*G*) graphic apparatus; (*K*) feeding trough; (*M*) metronome; (*B*) bell.

Besides, if simultaneously with the administration of food we introduce some other stimulus which is in no way connected with food and may even be so far unknown to the animal (the sound of a bell or metronome, for instance), and repeatedly coincide this stimulus with the administration of food, the effect of the stimulus alone preceding food will produce salivation. These reflexes caused by spontaneous (conditioned) stimuli have been called by Pavlov "conditioned reflexes."

If the conditioned reflex is somewhat varied, as, for instance, if the metronome is set at 60 beats per minute instead of the previous 120 beats, and if no food is then given to the dog, the animal learns to

differentiate between the two stimuli and does not respond by salivation to the metronome set at 60 beats. Thus, according to Pavlov's term, differentiated inhibition is formed.

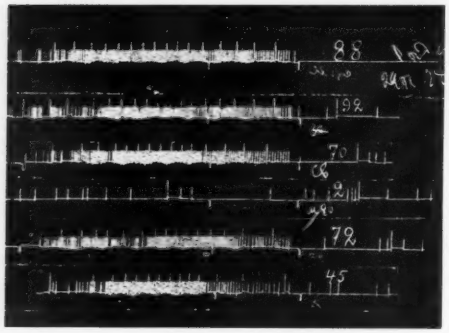

Fig. 2. Diagram of salivary reflexes of a dog before exposure to light. Between the two dashes below the line the relative salivary secretion is shown; further to the left appears the absolute salivary secretion (while taking food).

Fig. 3. Radiated field on the cranium of the dog (natural size).

It has been established that the intensity of salivation depends on the strength of the stimulus: the stronger the latter, the greater the quantity of the saliva secreted in response to the conditioned reflex produced by it. Thus, it has been established in Pavlov's laboratory that, for instance, an electric bell is a somewhat stronger stimulus than the metronome; a whistle producing tone "do" is a weaker stimulus, a still weaker stimulus is light, while a tactile stimulus is the weakest. A normally activated dog responds to any one of the stimuli by a corresponding number of saliva drops in a given unit of time. The number of drops will be the greater, the stronger the stimulus. The saliva of an experimental dog is obtained through a surgical fistula on Stenson's duct or one of the parotid glands.

The experiment is carried out as follows: The dog is placed in a special sound-proof chamber (Fig. 1) so that no foreign sounds shall distract its attention. A small glass bulb is fixed to the salivary fistula by means of Mendeléeff's putty, the bulb and the rubber tubing attached to it being completely filled with water. A drop of saliva upon entering the bulb produces a shifting of the liquid in the system of rubber and glass tubes which are provided with a graded scale. The glass tube with the scale is in the observation room outside the chamber. The drops of the liquid contained in the glass tube and consisting of electrolyte, in running out fall on metal contacts, thus forming a circuit in the registering device where every drop of saliva is registered. Figure 2 shows a sample of such automatic registration. The stimuli are set in operation either by electricity or by a pneumatic device from the observation room. The bowl containing food (meat and bread crumbs) is also placed before the dog by similar devices.

So far, I have been experimenting on three dogs. Two of them, "Rogdai" and "Riji," I received from Dr. Pavlov as specimens which had been used in his laboratory for two or three years and had firmly established conditioned reflexes before I started working with them. The third dog, "Rody" (Radium), is beginning to form conditioned reflexes.

Dog No. 1 (Rogdai), a mongrel, five or six years of age, of calm disposition, has a fistula on the right Stenson's duct.

Fig. 4. Showing epilation on the head of the dog, corresponding to the radiated field.

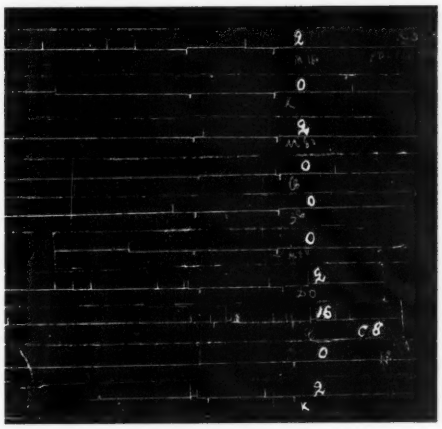

Fig. 5. Diagram of salivary reflexes. Nearly all the exciting factors gave negative results.

The animal always eats with avidity, works with much readiness, and even jumps in the stand of his own accord. His reflexes are regular and stable. The ratio between the strength of the stimulus and the amount of saliva is permanent. Thus, on the ground of a large number of experiments it was possible to estimate the following mean figures (in drops), showing the interrelation between the stimuli and the amount of saliva:

1.	Bell	86.5	drops
2.	Metronome at 160 beats per minute	84	"
3.	Tone "do"	65.6	"
4.	Light	50	"
5.	Tactile stimulus (pricker)	36	"
6.	Metronome at 80 beats per minute	2.4	"

My first experiment with the dog was made on Dec. 5, 1927. The total number of experiments performed on Rogdai up to May 8, 1928, was 103. With a few exceptions, the experiments were carried out daily.

Samples of protocols of two normal experiments preceding exposure follow:

If we take the mean figures for the period of one week following from Feb. 23, *i.e.*, for the week preceding exposure, we shall see that they are as follows:

Bell	86.5
Metronome at 160 beats	84
Tone "do"	66.6
Light	50
Pricker	36
Metronome at 80 beats	2.4
Differentiated inhibition	

In order to estimate the effect of the roentgen laboratory on conditioned reflexes, the dog was brought to the Institute of Roentgenology on Dec. 28, 1927, and tied to the table, where it was subjected to a sham exposure under conditions which entirely corresponded to those of an actual exposure. Numerous further experiments have shown that such sham exposures have not the slightest effect on conditioned reflexes.

On Feb. 29, 1928, at 1 P.M., the dog was brought to the Institute of Roentgenology and tied to the table in the roentgen laboratory, where radiation within the region of the cerebral hemispheres was applied through a field of 15.2 sq. cm. (Figs. 3 and 4). Technic: Neo-Intensiv with condensers; tension near the tube, 180 K.V., filters 0.5 mm. Zn plus 3 mm. Al, giving a total of 2 H.E.D., or about 1,500 r.

Subsequent to radiation the dog's behavior and appetite were absolutely normal. During the week following radiation the mean values of its reflexes varied but slightly from those observed during the week which preceded exposure. The only

noteworthy phenomenon was that the positive induction which had appeared subsequent to differentiated inhibition previous to radiation, at times was changed into negative induction in the second half of the week following radiation. By the term "induction" we mean the condition of the cerebral cortex which immediately

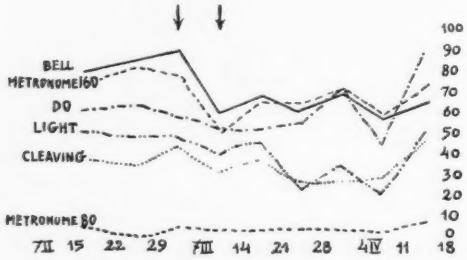

Fig. 6. Curves of relative salivary reflexes with various exciting factors. Arrows indicate the radiation.

follows differentiated inhibition. Induction may be positive, *i.e.*, when the condition of inhibition is followed by that of excitation, or negative, when the inhibitory condition lasts. In the first case the reflex following inhibition is considerable; in the second case, the reverse.

Thus, previous to radiation the bell sounding after inhibition produced 95 drops of saliva; the metronome, 110 drops, and the tone "do," 72 drops. After exposure to roentgen rays the bell sounding after inhibition produced 88–86 drops, the metronome, 45.

After the experiment carried out on March 7, 1928, at 2 P.M., the dog was exposed to radiation as before, with the sole difference that this time it was given a dosage of 3 H.E.D., *i.e.*, 2,200 r. On March 8 nothing abnormal could be observed in the dog's behavior; all conditioned reflexes were considerably decreased. On March 9 the reflexes were still further decreased. The protocol follows. On March 10 the dog was quite inert, was unwilling to jump on the stand, refused food, no borborygmus could be heard.

EXPERIMENT NO. 64, MARCH 10, 1928

All stimuli produced reflexes equal to zero with the exception of the light stimulus, which produced 16 drops of saliva (Fig. 5).

On March 11 the dog looked quite braced up and ate and jumped on the stand with readiness. However, throughout the week following radiation the reflexes were considerably decreased.

Thus, if we compare the mean figures from March 1 to March 7, *i.e.*, for the week preceding radiation, with those observed from March 8 to March 14, *i.e.*, for the week following radiation, we shall have the following values:

Bell	91.8	62.0	70.6
Metronome at 160 beats	79.3	52.0	66.5
Tone "do"	59.8	53.7	53.4
Light	50.0	42.6	47.4
Pricker	44.7	33.5	40.0
Metronome at 80 beats	5.8	5.4	5.5

Thus a considerable decrease in all reflexes is observed which chiefly tells on such reflexes as are produced by the stronger stimuli. Besides, it is of interest to note the following very important fact:

Thus, on March	12,	subsequent	to	differentiation,	light	produced	22	drops
"	"	"	13	"	"	"	pricker	"	22	"
"	"	"	14	"	"	"	bell	"	75	"
"	"	"	15	"	"	"	tone "do"	"	44	"
"	"	"	17	"	"	"	light	"	12	"
"	"	"	19	"	"	"	tone "do"	"	15	"
"	"	"	22	"	"	"	light	"	24	"
"	"	"	23	"	"	"	pricker	"	12	"
"	"	"	24	"	"	"	bell	"	22	"

beginning with the fifth day following radiation, marked negative induction was

observed subsequent to differentiated inhibition (metronome at 80 beats).

Beginning with the fifth week following radiation, the reflexes became stronger and gradually reached their normal value toward the end of April.

laboratory. The total number of experiments made for my investigations with this animal was 93. During the period from Jan. 26, 1928, to Feb. 21, 1928, and on May 9, 1928, its brain was exposed to a dosage of 3,500 r. As shown

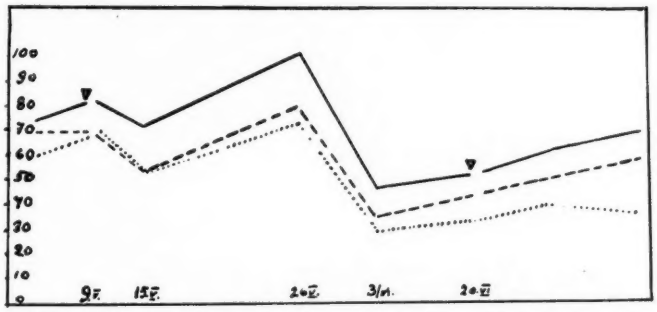

Fig. 7. Curves of salivary reflexes with various exciting factors. Reflexes on the strokes of a metronome are shown by the continuous line; reflexes caused by the tone "do" shown by line of dashes; by light, the dotted line. The black triangles indicate the application of radiation.

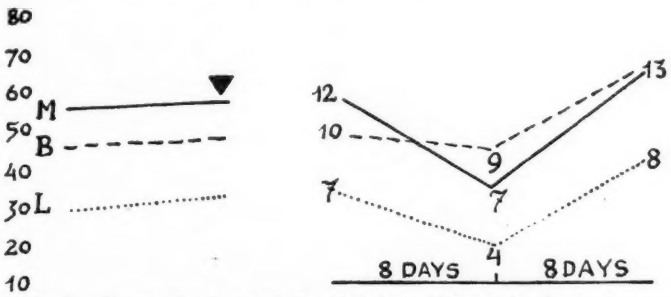

Fig. 8. Curves of reflexes of the third dog: (*M*) exciting factor (metronome, in this case); (*B*) bell; (*L*) light; black triangle, radiation.

Previous to the third exposure the dog perished, due to an accident on May 8, 1928.

In summarizing the results of experiments made on this dog we may say that radiation of the brain caused a marked decrease of its reflexes, and that this decrease was particularly manifest in the case of the stronger stimuli, *i.e.*, the bell and the metronome. Besides, considerable successive inhibition (negative induction) following differentiation was observed (Fig. 6).

Dog "Riji," Irish setter, adult animal, had worked for a long time in Dr. Pavlov's

in the curve (Fig. 7), this resulted in a marked decrease of all the reflexes in the first six days, followed by a considerable increase of reflexes in the next eleven days. During the following eight days the reflexes once more decreased, thereafter remaining at these lower values. It is of interest to note that the auditory stimulus tone "do" which, previous to radiation and in the first six days following it, produced fewer drops of saliva than did light, began producing more saliva than the light stimulus after the sixth day following radiation. This phenomenon remained permanent until the animal's death.

On June 20, 1928, the dog was exposed to secondary radiation (dosage 2,800 r). After exposure, a slight increase of reflexes was observed, which, however, remained below the values observed in the dog previous to the first exposure, and later they again developed a tendency toward decreasing (Fig. 7). On Sept. 15, 1928, the dog was killed and dissected.

My work has not yet been completed but, even now, I am able to say that my presumptions have been confirmed. Roentgen rays do affect the activity of the cerebral hemispheres, apparently causing an inhibitory condition.

In the future my experiments will be carried out on a larger scale. A special laboratory for the purpose of studying, by means of the conditioned reflex method, the effect produced by roentgen rays and radium on the activity of the cerebral hemispheres is being equipped at the Institute. It seems to me that the application of this method is full of possibilities.

The method of conditioned reflexes not only enables us to study the effect of roentgen rays and radium on nerve cells, but it also helps us to solve a number of problems connected with the physiology of the cerebral hemispheres. It does not seem im-

EXPERIMENT NO. 52, DEC. 29, 1928

Time	Stimulus	Latent period (sec.)	Time of delay (period elapsing between the moment when the stimulus begins acting and the time when the dog receives food) (sec.)	Number of saliva drops
9:30	Tone "do"	3	30	65
9:38	Metronome at 160	3	30	82
9:44	Metronome at 80	3	30	0
9:50	Bell	3	30	95
9:58	Pricker	4	30	25
10:04	Light	4	30	53

EXPERIMENT NO. 53, FEB. 29, 1928

(The day of exposure to roentgen rays; 3 hours previous to it)

Time	Stimulus	Latent period (sec.)	Time of delay (sec.)	Number of saliva drops
9:31	Metronome at 160	2	30	88
9:38	Bell	3	30	92
9:47	Light	4	30	70
9:53	Metronome at 80	9	30	2
9:58	Tone "do"	3	30	72
10:05	Pricker	4	30	45

EXPERIMENT NO. 63, MARCH 9, 1928

Time	Stimulus	Latent period (sec.)	Number of drops
9:32	Bell	5	48
9:40	Pricker	3	20
9:46	Tone "do"	3	40
9:53	Metronome at 80 beats	9	4
9:58	Light	3	30
10:07	Tone "do"	4	30
10:15	Pricker	5	35

possible that by applying rigorously limited local radiation, with radium in particular, we shall be able to localize definite centers of conditioned reflexes produced by this or the other receptive apparatus of our senses. No light has so far been thrown on this tremendously important problem.

Further, by applying the method we shall be able to study the effect of the radiation of ductless glands on the activity of the cerebral cortex. Thus, I intend to carry out investigations which help to determine by the conditioned reflex method the effect produced by the radiation of the puberty glands on the activity of the cerebral hemispheres.

We shall also undertake the study of conditioned reflexes in children exposed to radiation for the treatment of fungous diseases of the scalp. So far, it has not been established whether or not radiation of the skull affects a child's brain. Apparently, if any changes are produced, they can be revealed only by the conditioned reflex method, as our clinical methods are much too crude for the purpose.

THE EFFECT OF ROENTGEN RAYS ON THE BRAIN

EXPERIMENTAL INVESTIGATION BY MEANS OF THE CONDITIONED REFLEX METHOD

By PROF. DR. M. I. NEMENOW, *Leningrad, U.S.S.R.*

From the State Roentgenologic, Radiologic, and Cancer Institute, Director, Prof. Dr. M. I. Nemenow

THE study of the effect of roentgen exposure on the activity of the cerebral hemispheres was first undertaken by me over four years ago, *i.e.*, in 1927.

Even the first findings served to show that evidently my suppositions were confirmed. Due to roentgen exposure the conditioned reflexes in dogs after a fairly short period of time showed certain deviations from such reflexes as had been previously firmly established. These changes, as a rule, revealed a primary increase of the reflexes, followed by their more or less lasting decrease (see curves). Besides, a qualitative deviation from normal reflexes was observed. Thus, a stronger stimulus produced a weaker response as compared to that produced by a weaker stimulus, and so forth.

The important findings I then obtained enabled me, in the Summer of 1928, to make a preliminary communication at the V All-union Congress of Roentgenologists and Radiologists and at the II International Congress of Radiologists in Stockholm.

However, realizing the importance of the subject, I put off the publication of my paper until the findings reported in my preliminary communications had been confirmed by further experiments and investigations.

Later, after a suitable laboratory, with a technically perfect chamber, had been equipped at the State Institute of Roentgenology and Radiology, the investigations were carried out along several different lines. The work was carried out in collaboration with Professor P. S. Kupalov, A. M. Ushakova, and Professor R. S. Lyman, of the United States of America. Histologic examination of the brain was performed in the case of some dogs in Munich by W. Scholz.

Besides, studying the conditioned reflexes in adult dogs, the brains of which had been subjected to roentgen exposure, I also started to expose to roentgen rays the brains of pups in whom conditioned motor reflexes were subsequently established. When the pups became adult dogs they were provided with salivary fistulæ and their salivary responses were then studied.

The peculiar conditions of a roentgen room were made familiar to the dogs at an early age; they were taught to lie motionless under the roentgen tube without being either anesthetized or fixed to the stand. This served to exclude the effect of such undesirable factors as an anesthetic or the sense of fear on the behavior of dogs.

Our further investigations fully confirmed the findings I reported in my preliminary communication. Likewise, we were able to observe a number of most interesting phenomena concerning dogs which had been subjected to radiation at an early age. Thus, we observed in radiated pups a tendency to walk in circles for several months subsequent to exposure to the roentgen rays. The dogs mostly walked in circles clockwise. They showed considerable delay both in growth and weight, as well as in mental development. With time, this backwardness was more or less overcome, depending on the dosage applied.

In dogs which had been exposed to radiation at an early age we observed epileptoid fits, occurring several weeks subsequent to exposure and sometimes recurring after a lapse of several months, the fits greatly re-

sembling genuine epilepsy in man. Obviously they were preceded by a condition of dimmed consciousness. This was followed by general convulsions and foaming at the mouth.

Further, we noticed that dogs exposed to roentgen rays either at an early age or when fully grown did not live long. Professor Kupalov and Professor Lyman, in their experiments, exposed adult dogs to heavy dosages of roentgen rays (15–20 H.E.D.), with the result that a marked decrease of reflexes was observed.

Having observed the epileptoid fits which developed in dogs after a considerable time had elapsed since exposure, and the early death of such dogs, which could hardly be accounted for by any other factor but radiation, we subjected the brain of one of the dogs to a histologic examination at Spielmeyer's laboratory in Munich. A detailed account of the findings will be reported in the near future by Professors Lyman, Kupalov, and Scholz.

The changes which were observed to occur in the cerebral tissue a considerable time subsequent to exposure threw a light on the question which, so far, had remained vague, namely, the radiosensibility of cerebral tissue. It is well known that the majority of investigators concerned with the study of the effect of roentgen rays on the cerebral tissue, ganglion cells in particular, of adult animals have been led to believe it to be completely insensible to roentgen rays. Such statements in the literature served as a stimulus to make me approach the problem by applying the conditioned reflex method for the study of the functional changes thus produced. The method served to prove beyond doubt the occurrence of functional changes in the cerebral cortex, which appear shortly after exposure.

Histologic examination, performed many months subsequent to the exposure of the brain to roentgen rays, revealed a further development of the process as characterized by marked microscopic changes. The negative results obtained by histologic examination and previously reported in the literature can be accounted for by the fact that the experiments were performed too soon after exposure, while the process had not yet attained the stage of development when it could be revealed by the microscope.

Here I should like to emphasize once more the idea which was the basis of my theory with regard to the biologic effect of roentgen rays.

Molecular processes caused in living tissues by any factor develop the slower, the longer the life, or, in other words, the greater the power of differentiation, characteristic of the elements of these tissues. This probably explains why the pathologic process produced in nerve cells by roentgen rays is so slow to develop. The consideration seems to apply equally well not only to roentgen rays but to other factors as well. It obviously refers both to separate cells and to organisms as a whole.

Thus we know that by applying coal tar we are able to cause the development of cancer as early as in four months' time in a white mouse, while in a rabbit the same process takes no less than a year to develop. In the case of man being subjected to the effects of a cancerogenous factor, the latter must necessarily be at work for a number of years before it results in cancer.

Professors Lyman and Scholz have established on our experimental animals that the changes observed in the cerebral tissues were the more manifest the greater had been the period which had elapsed between exposure to roentgen rays and the death of the dog. Thus, in several months' time subsequent to exposure they observed multiple necroses of the cerebral tissues, due to the hyaline degeneration of intracerebral arteries. In the earlier stages following radiation marked symptoms of encephalitis were observed. These workers believe the changes in the cerebral vessels to be primary, and the above-described changes in the nerve tissue (necroses) to be secondary. However, it is hard to form any definite conclusion on the subject as

it is the entire brain which is exposed to roentgen rays, the cerebral vessels included. The latter doubtless reveal morphologic changes at an earlier period and after lighter dosage than do the nerve cells of an adult animal. Personally I consider that the injury to nerve cells by roentgen rays may also be of a primary nature. This is confirmed by the changes which occur in conditioned reflexes soon after exposure, as well as by the symptoms of encephalitis which are also observed at a relatively early stage. However, I repeat, the question has not yet been solved, for under the circumstances we have to deal with the effect of roentgen rays on the brain as on a complex of interdependent tissues. Our investigations along these lines are being continued and the results will be reported.

A NEW METHOD FOR THE RADIOGRAPHIC EXPLORATION OF THE MEDIASTINUM AND CONCEALED PORTIONS OF THE PULMONARY FIELDS

By PAUL M. ANDRUS, M.D., F.R.C.P. (C.), *London, Canada*

From the Mara Research Laboratories at the Queen Alexandra Sanatorium[1]

PART I. THE CONCEALED PORTIONS OF THE PULMONARY FIELDS

SUBSTANTIAL volumes of lung tissue are eclipsed and concealed by the mediastinal structures in conventional roentgenograms of the thorax. The frequency with which important or determinative structures lie in these hidden areas is unknown. In the press of daily routine we are prone to forget the very existence of these parts or to speculate on their inherent possibilities. That it is possible for these areas to be the seat of obscure disease must be conceded, and the finding of tubercle bacilli in the sputum of individuals in whom no parenchymatous shadows are demonstrable is not rare. The radiographic shadows are frequently well within the normal limits in the presence of clinical pulmonary disease, and metastases might, of course, be deposited in these concealed parts. Unexplained hemoptysis is also a rather frequent condition which might conceivably have its origin in such hidden places. The extent of these concealed areas is shown in the accompanying tracing from Eycleshymer and Shoemaker's "A Cross-section Anatomy"[2] (Fig. 1). The converging heavy lines indicate the path of the rays from a six-foot focus-film distance, and it is apparent that the pulmonic fields in the areas medial to these lines are not made visible by this projection. The volume of lung tissue thus concealed is large at the bases, especially the left, but becomes relatively small above the level of the bifurcation of the trachea.

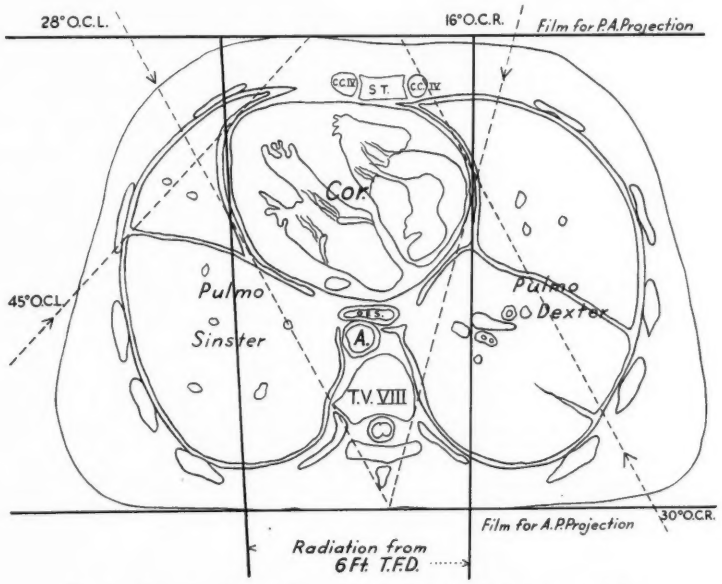

Fig. 1. Cross-section of thorax at level of eighth thoracic vertebra.

[1] Assisted by the National Research Council of Canada.

[2] Courtesy D. Appleton & Co., publishers.

We accordingly attempted to radiograph these concealed portions of the lungs. The customary oblique film, for which the patient is rotated, may be used to project these areas onto the film, but has the very decided disadvantage of removing the part some distance from the photographic material. An equally important disadvantage of the oblique method for this purpose is the difficulty of measuring the angle of rotation of the subject, a measurement which it will be seen from the diagram must be possible of, at least, some approximation of control. However, if the area to be examined is placed flat against the film in the usual manner (A-P or P-A), and the tube off-centered to a suitable degree to the same side, the concealed portions of the lungs may be projected onto the film with satisfactory detail. This technic we term "off-centered exposures" and designate O. C., R. or L.[3] (right or left), with the number of degrees, and P-A or A-P position.

1. RADIOGRAPHY OF THE LUNG MARGIN ANTERIOR TO THE RIGHT BORDER OF THE MEDIASTINUM

This area is not voluminous and does not extend above the bifurcation of the trachea. With the anterior chest wall in contact with the film, this area may be radiographed by off-centering the tube about 30 degrees to the right (Fig. 1). It is to be noted that the volume of lung superimposed on the anterior margins is rather less in this off-centered projection than in tube-centered postero-anterior exposures.

2. RADIOGRAPHY OF THE LUNG MARGIN ANTERIOR TO THE LEFT BORDER OF THE MEDIASTINUM

This margin lies chiefly between the second and fourth costal cartilages. However, it is not infrequently the seat of crepitant râles in tuberculous disease as well as a focus of bronchiectatic dilations, and its visualization may therefore be important. An off-centering to the left of 45 degrees (P-A exposure) is necessary to project this margin onto the film. The upper portions are apt to be superimposed on the shadow of the sternum and visibility thus impaired.

3. RADIOGRAPHY OF THE LUNG IN THE RIGHT PARAVERTEBRAL FOSSA

The maximum of lung tissue that it is possible to radiograph in this location is obtained by lining up the focal spot of the tube with the right border of the mediastinum and the right margin of the spine, using an antero-posterior projection. Moderate new tissue is thus revealed in the post-cardiac area and less important volumes above this level. Above the bifurcation of the trachea no significant gain is apparently made as compared with tube-centered exposures. An average off-centering of 16 degrees to the right with an antero-posterior projection is suitable for radiography of this area (Fig. 1). It will be noted that a rather small volume of lung tissue adjacent to the posterior mediastinum (on both sides) cannot be visualized in this projection.

4. RADIOGRAPHY OF THE LUNG IN THE LEFT PARAVERTEBRAL FOSSA

The increase in lung tissue radiographable in this location is greater than on the right. The maximum of tissue is radiographed by lining up the focal spot of the tube with the left margin of the spine and the left border of the heart, in an antero-posterior direction. An off-centering of 25 degrees may be used as an average for this area, although the angle varies at different levels, according to the width of the heart. In radiographing the paravertebral area on either side, the angle to which the tube is off-centered must be correctly ascertained, else either the heart or the spine will be projected over the lung area it is desired to study. In the case of an enlarged or dislocated heart, the angle of off-centering would have to be

[3] R. and L. refer to the patient in all positions.

increased and the amount of new lung made visible would be lessened. The angle will also vary with different individuals. It is wise to study cross-sections of the thorax at all levels to become familiar with the projections.

5. RADIOGRAPHY OF THE MEDIAL SURFACE OF THE UPPER LOBES

Although the volume of lung tissue concealed by the mediastinum above the bifurcation of the trachea is small, it is theoretically possible for disease, such as subpleural caseous tubercles, to lie in this area. An improved visualization of the medial surfaces of the upper lobes may be possible by off-centered exposures of about ten degrees to each side.

TECHNIC

The tube position for off-centered exposures of these concealed lung areas, is tabulated for convenience (Table I).

TABLE I.—TABULATION OF PROJECTION FOR OFF-CENTERED EXPOSURES

Lung area	Projection	Degree of off-centering
Right ant. margin	P-A	30° R.
Lt. ant. margin	P-A	45° L.
Rt. paravertebral area	A-P	16° R.
Lt. paravertebral area	A-P	25° L.
Medial surface of upper lobes	P-A	10° R. and L.[3]
Tracheal bifurcation	P-A	35° R. and L.

The following method may be used for placing the tube at the required angle, for trial or occasional exposures. Construct upon the floor, as with colored crayon, a perpendicular to the center of the film and at four feet from the film construct a second line at right angles. Mark off to right or left of this intersection the distance given opposite to the required angle in Table II. On the radius joining this point with the center of the film may be measured any desired target-film distance. A plumb line may be used to place the focal spot above the determined point. It is important that the long axis of the tube be placed at right angles to this radius, *i.e.*, that the focal spot be "pointed" at the center of the film. This is especially important in the case of line focus tubes.

A much simpler and more flexible arrangement, however, when such exposures are made with any frequency, is to mount

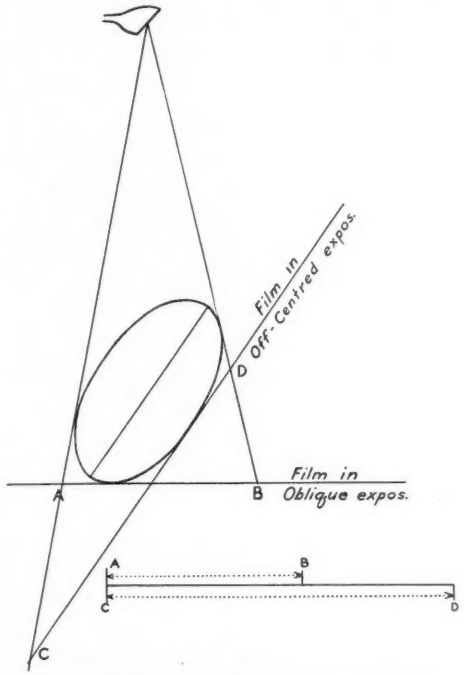

Fig. 2. Oblique view off-centered projection.

TABLE II.—TABLE FOR OBTAINING REQUIRED TUBE ANGLE FOR OFF-CENTERED EXPOSURES

Angle (degrees)	Off-centering (at 4 ft. perpendicular distance) (in.)
10	8.5
15	12.9
20	17.5
25	22.4
30	27.7
35	33.6
40	40.3
45	48.0
50	57.2

the cassette holder on a heavy plank base and to insert a pin through this into the floor below the center point of the film. The cassette may then be rotated instead of moving the tube stand. A scale of angles should be provided. With this device a set of exposures may be made

about as quickly as are routine chest radiographs.

It is important to provide a cassette holder about which the patient may wrap the arms in order to get the scapulæ and muscles out of the way. The horizontal type of cassette changer is, for this reason, not well suited to off-centered exposures.

The patient should be off-centered on the cassette toward the same side as the tube, to such degree as to project the desired parts onto the center of the film. Without this precaution the areas to be examined may be projected off the film.

RESULTS AND DISCUSSION OF RADIOGRAPHY OF CONCEALED PORTIONS OF PULMONARY FIELDS

We have radiographed in this manner the concealed portions of the pulmonary fields in a number of individuals having positive sputum or frank hemoptysis but in whom no parenchymatous disease was demonstrated in tube-centered exposures; also in a number of individuals with chronic non-specific basal disease. We have not demonstrated "new" shadows in any of this group, which is, of course, no evidence that such may not occur.

In the case of acute or chronic bronchopneumonias or metastases, it is, of course, possible that they may be confined to these concealed areas; it seems probable, however, that they would as a usual thing also occur elsewhere. The method is not necessary for the visualization of lipiodol-filled spaces as these may be radiographed through the heart.

In the case of tuberculosis, it seems improbable to this author that such hidden pulmonary foci are customarily the source of tubercle bacilli in the case of those sputum-positive cases showing no parenchymatous shadows. This for the following reasons:

1. Localized pulmonary tuberculosis of limited extent and confined to a base, is unusual in the visible portions of the lung-fields, and is, therefore, probably also unusual in the smaller concealed portions.

2. Primary basal tuberculosis is usually a rapidly progressive disease, whereas the outlook in sputum-positive cases without demonstrable lesions is uniformly good. The mediastinal glands are a possible source of bacilli in such cases.

PART II. THE MEDIASTINUM

In the preparation of films of the concealed portions of the pulmonary fields by means of off-centered exposures as in the preceding section, there was noted a high visibility of the bifurcation of the trachea and main stem bronchi, such as is not observed in any of the conventional projections including the oblique.

In tube-centered exposures these structures are, of course, covered by the spine, while in oblique exposures the main stem bronchi are projected close together or overlapping, and their visualization is of a low order.

The mechanism of projection in off-centered exposures is shown in Figure 2. It is seen that the size of the image C D for the off-centered exposure is considerably greater than is the image A B resulting from the oblique exposure. These measurements are superimposed at the bottom of the diagram for convenience of comparison. The image is magnified in the off-centered exposure because of the angle between the film and the incident radiation. This magnification occurs in the horizontal but not in the vertical plane. It is thus apparent that the separation of the images of the main stem bronchi in off-centered exposures is the result of distortion or magnification in the horizontal plane. Such a tracheal exposure is shown in Figure 3. Associated structures, such as glands, may thus be possible of visualization in more nearly their correct relations to the trachea and main stem bronchi.

In addition, the scapula and scapular muscles can be much better removed from the fields when the patient is flat against the cassette than when he is obliquely placed. Also, as previously noted, it is most difficult to measure or duplicate an

angle of obliquity between the patient and cassette, whereas the angle between a cassette and tube is capable of measurement with any required degree of accuracy.

TECHNIC

An off-centering of 35 degrees is necessary to uniformly expose the carina, although in most subjects 30 degrees is sufficient. An off-centering to the right (P-A projection) gives the most satisfactory view and displays most of the left main stem bronchus. To be sure of a full visualization, however, 35 degrees off-centered exposures from both right and left should be made.

The patient's arms should be wrapped around the cassette to remove the scapulæ as much as possible from the fields. In addition, the patient should be off-centered on the cassette to the same side as the tube to such a degree as to project the posterior mediastinal contents to the center of the film. To attain this, the patient's chin should usually be placed only two or three inches from the edge of a 14-inch cassette.

Considerably greater energy is necessary than for tube-centered exposures of the pulmonary fields, and one need aim at a less high degree of contrast. The pulmonary fields are, of course, thus greatly over-exposed.

DISCUSSION AND RESULTS

Using this method, glandular masses in both adults and children are not infrequently visible which are not seen in tube-centered or the conventional oblique exposures. Their position in relation to the trachea or main stem bronchi is also apparent. Such visualization depends, of course, upon the presence of calcium, because of the density of the vascular structures with which they are contrasted. Complete calcification is not necessary, as scattered lime may indicate the presence of caseo-calcareous deposits.

Fig. 3. Off-centered view of tracheal bifurcation.

It would seem that an improved visualization of the occurrence, extent, and relationships of the glands in the region of the tracheal bifurcation can be expected to constitute an important advance, especially in the study of tuberculous infection in children.

We present the suggestion of off-centered thoracic exposures for the radiography of the concealed portions of the pulmonary fields and the region of the tracheal bifurcation, in anticipation of a more widespread experience than is possible in a single center, determining whether the procedure has anything of importance to add to our medical methods. A further application of the method should be in the study of the mobility of the roots of the lungs, as suggested by Macklin (1).

REFERENCE

(1) MACKLIN, CHARLES C. The Dynamic Bronchial Tree. Am. Rev. Tuberc., **25,** p. 393.

CASE REPORTS AND NEW DEVICES

A SIMPLE LABORATORY CHRONOGRAPH[1]

By CHARLES WEYL, F. MAURICE McPHEDRAN, M.D., *and* S. REID WARREN, JR., *Philadelphia*

For the solution of a particular problem[2] it became necessary to design an instrument for measuring accurately to one-thousandth of a second the time interval between the instant of the beginning of a pulse of air produced by manual impulse of a lever and transmitted along a tube, and the beginning of an x-ray exposure actuated through a mechanical-electrical system by the manual impulse. It is believed that the chronograph designed for this purpose may be valuable for laboratory use in connection with other problems.

The chronograph consists of a drum upon which is mounted a ten-inch strip of standard (35 mm.) motion picture film, a device for rotating this drum at a constant speed of one revolution per second, and a system for exposing a part of the film through a small aperture to a light source at the instant of operation of the lever. Also, there is recorded on the same film through a similar aperture the x-ray impulses from the tube indirectly caused to operate by the operation of the chronograph lever. A detailed description of these parts, and a description of the method of operation of the instrument, will follow in three sections.

FILM DRUM

The film drum and its light tight case are shown in detail in Figure 1. The rotatable drum *A* is fixed upon shaft *B*, which is slotted at one end and carries a brass disc *C* at the opposite end, has a circumference of 10 inches, and is of such width that a strip of 35 mm. motion picture film fits snugly between the two shoulders. This assembly is shown inverted in Figure 1-*A*. Spring clips at each side (one visible at *D*) are arranged to hold the ends of the film. Around the circumference, by means of shellac in a groove in the brass drum, a strip of intensifying screen *E* is held in such a way that the surface of the screen is in contact with the film when it is clipped in place. In the cap *F* of the light-tight box, there is constructed a bearing for the shaft *B*. This entire assembly (Fig. 1-*A*) fits into the remainder of the light-tight case *G* in such a way that the cap *F* clamps, by a forced fit, around the top of *G* (Fig. 1-*B*). A second light-tight bearing is so arranged that the end of the shaft *B* projects below the bottom of *G*. Two holes, *H* and *I*, are drilled perpendicular to the face plate through the drum holder: a cylindrical shutter *J* closes or opens these two apertures. This assembly is mounted, as part of the mechanism described below, in the position shown in Figure 1-*B*. The light-tight case *G* remains stationary, while the shaft *B*, the drum *A*, and the disc *C* rotate at a uniform speed of one revolution per second.

DRIVING MECHANISM AND LIGHT SOURCE

The assembled chronograph is shown in Figure 2. The wooden cabinet is provided with a shelf *K*: an electric governor-controlled phonograph motor is mounted under this shelf with the shaft projecting vertically at the center of the film drum *G*. A neon lamp *L* is arranged so that, operated by 60 cycles, 110 volts, it illuminates the synchronizing disc *C* while the motor is in operation. The governor screw *M* can be adjusted until the lines of the synchronizing disc appear to be stationary—there are 120 of these radial lines spaced three degrees apart. The synchronous speed is 60 revolutions per minute or one revolution per second. It will be seen that the front plate, on which the holes *H* and *I* appear in Figure 1-*B*, drops into a slot at *N* in a stationary piece fastened to the cabinet.

A line filament oscillograph lamp (operating voltage 4.5 volts) is mounted within the lead covered box *O* in such a way that light will be projected directly from the filament through the hole *I* to the rotating film, provided the path is unobstructed. This lamp is operated by means of a small transformer mounted within the cabinet.

The lever, with the handle appearing outside the cabinet at *P*, extends along the face of the plate, containing holes *H* and *I* at the level of the lower hole *I*. This lever extends back to *Q* and is terminated in a plate.

For the purpose at hand, it was desired to record the time of incidence of a pulse of air at the end of a tube connected to the chronograph externally. The following de-

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[1] This instrument was developed in the process of an investigation at the Moore School of Electrical Engineering, University of Pennsylvania, under a grant by the National Tuberculosis Association.

[2] F. M. McPhedran and Charles Weyl: Automatic Synchronization of Roentgen-ray Exposures. Am. Jour. Med. Sci., 1925, **169**, 510.

Idem: The Application of Automatic Synchronization of X-ray Exposures to the Study of Intra-thoracic Movements. Proc. Am. Phil. Soc., 1925, **69**.

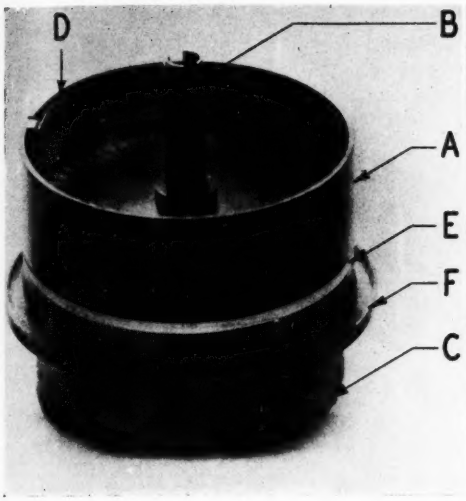

Fig. 1-*A*. See text.

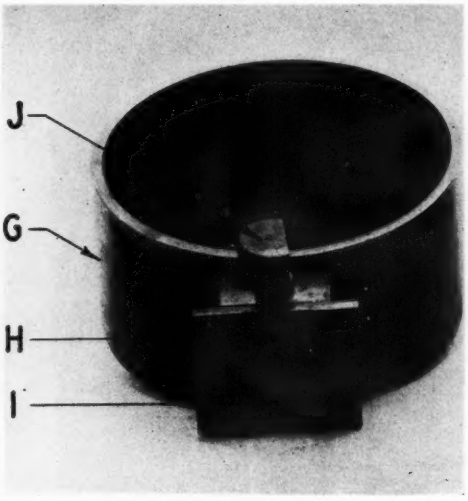

Fig. 1-*B*. See text.

scription shows the method. For other problems, the lever may be arranged to close the contacts of a switch in an electrical circuit or to allow light to be incident suddenly on a photo-electric cell.

Fixed in the back of the cabinet there is a brass piece with a rubber diaphragm to which connection may be made by a rubber tube from the outside of the cabinet. By pushing the lever handle *P*, the plate *Q* impinges against the rubber diaphragm sending a pulse of air along the tube which is connected externally. At the instant the plate *Q* strikes the diaphragm, a hole drilled across the lever coincides with the hole *I* so that light from the source goes through the aperture to the moving film. Thus the beginning of the light spot on the developed film marks the time of the manual impulse of the diaphragm.

The upper hole *H* appears one-quarter of an inch above the level of the top of the box *O*. The beam of x-ray along the line 1–2 will go through the hole *H*, impinge on the rotating film and also the strip of intensifying screen *E*. The entire front of the cabinet is shielded with lead except for a small aperture to provide for the beam 1–2 with the lid closed.

OPERATION

The following outline indicates the method of use of the instrument:

(1) Employing a focal spot-film distance of about two feet, place the instrument directly in front of the focal spot of the x-ray tube in such a way that the focal spot lies along the line 1–2. Pull the actuating lever *P* forward (away from the box).

(2) Load the drum in the dark room, being sure that the shutter *J* is closed.

(3) Mount the drum in the chronograph. Start the motor and adjust the speed to 60 revolutions per minute by means of the synchroscope. Turn off the synchronizing lamp. Open the shutter and close the lid of the instrument.

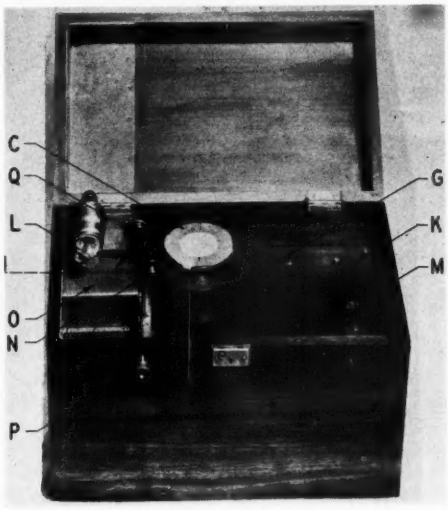

Fig. 2. The chronograph. See text.

(4) Operate the lever P by quick manual impulse. At the time the brass plate Q impinges on the rubber diaphragm, light passes through to the film momentarily. A short time later, the x-ray tube, actuated by this pulse, becomes excited. The first and successive x-ray impulses are recorded on the film through the hole H in the form of dots. Following operation, it is necessary to turn off the current supplying the chronograph lamp. The lever P is then pulled back to the original position; the lid is opened, and the shutter J is closed.

(5) Remove the drum to the dark room and develop about four minutes in x-ray developer. A sample copy of a film taken in this manner is shown on this page in Figure 3.

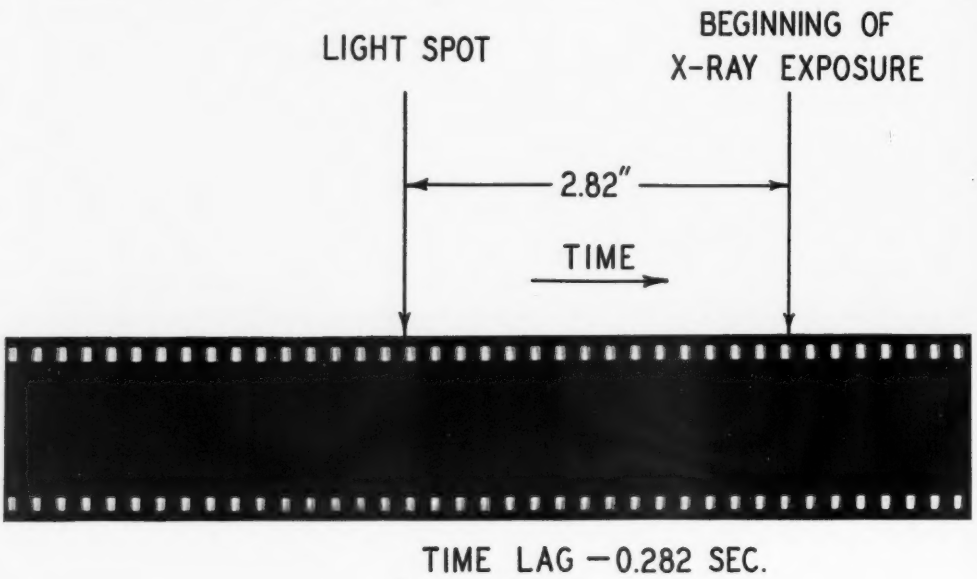

FIG. 3. A sample film.

The technic which has been employed most successfully is as follows: Focal spot-film distance, 24–30 in.; x-ray tube voltage, 70–80 K.V.P.; x-ray tube current, 100 ma.; time of exposure, $^1/_{60}$ second or more.

CARCINOMA OF THE STOMACH[1]

REPORT OF A CASE TREATED BY ROENTGEN THERAPY

By JOSEPH FRIEDMANN, M.D., *New York*

My object in reporting this case of carcinoma of the stomach is not so much that I wish to present anything particularly different from other x-ray findings but that my pre-operative diagnosis was that of a benign tumor or papilloma.

This case was referred by Dr. A. J. Walscheid for roentgenographic examination Feb. 14, 1927. Roentgenoscopic examination of stomach after a barium suspension meal shows that the stomach is situated to left of median line, greater curvature is even, and is 4.5 inches below the umbilicus. On palpation near the pylorus, a distinct mass about 1.5 inches in size, not movable, is felt between the palmar surfaces of the fingers.

Films taken in the upright, prone, and in the right lateral view, show that near the antrum of the stomach there is a faint irregular rarefaction, $^1/_2 \times {}^7/_8$ inch in size: the first portion of duodenum is somewhat irregular. Examination, six hours after the barium suspension meal, shows a faint residue in the stomach. Rest of gastro-intestinal tract is negative.

[1] Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

Fig. 1. Showing a faint irregular rarefaction near antrum of stomach $^3/_8 \times {}^7/_8$ inch in size; first portion of duodenum irregular (Feb. 14, 1927).

Fig. 2. Showing gastro-enterostomy opening which functions normally (Dec. 31, 1928).

History.—Seven months ago, J. P., aged 43 years, began to have discomfort about one hour after meals, frequently vomiting his entire meal. He has lost from 13 to 20 pounds in weight; at times he gains only to lose again.

Operation was performed March 10, 1927. A subtotal gastrectomy, Balfour method, jejunal-jejunostomy was performed.

Report from Pathological Laboratory.—The specimen is composed of a portion of tissue removed from the pyloric extremity of the stomach. There is an ulcerated area, $3^1/_3$ cm. in diameter at the lesser curvature. This lesion presents a definite circumscribed margin with crater-like edges. Section shows that the lesion is confined to the mucosa and does not infiltrate the submucosa.

Microscopic examination has been made of sections through the edge of the ulcerated area of the pylorus, and also at the base. Examination of the structure at the edge shows that a portion of the surface is covered with mucosa and its glands, but the submucosa has been replaced by a tumor process which is characterized by atypical columnar epithelial cells with an alveolar arrangement. These cells vary in size and shape and they contain a vesicular nucleus; an occasional mitotic figure is observed. The stroma is scanty, and is densely infiltrated with round inflammatory cells and polynuclear leukocytes. In areas in which the mucosa is not observed, there is some necrosis on the surface. Microscopic examination of sections at the base shows complete absence of the mucosa and muscularis mucosa. The submucosa is completely replaced by a tumor process characterized by various sized groups of atypical epithelial tumor cells in a cellular connective tissue stroma. This process has infiltrated the muscle coats but does not extend entirely through them.

Diagnosis.—On March 13, 1927, the diagnosis was carcinoma of the stomach. The patient was referred to me again on April 26, 1927, for a series of deep roentgen treatments. To the radiologist, this case is interesting because of deep roentgen therapy following a gastrectomy. Very little therapy for this ailment has been used in America.

When one observes the wonderful results which were obtained in this case, and in view of the microscopic diagnosis, and the immediate and late operative results, I feel that we should give some credit to deep roentgen therapy. I have always had great confidence in the use of this post-operative mode of treatment for carcinoma of the stomach. This case was perfectly well for four years, and free from all stomach symptoms of any kind, thereby firmly establishing my confidence in the application

of deep roentgen therapy in all cases of post-operative carcinoma of the stomach. Holfelder's technic was used.

Fig. 3. Specimen removed at operation.

The roentgenologist should always witness the operation to acquaint himself with the extent of the lesion, the amount of glandular involvement along the lesser and greater curvature, lig. gastricum, etc., as well as other metastasis. In fact, he must mentally visualize the entire pathology, thereby enabling him to apply the rays at the proper angle. It should always be remembered that care must be taken not to radiate the kidneys, suprarenals, pancreas, spleen, and lungs, to avoid any anatomical damage, and subsequent physiological dysfunction.

The patient receives a dosage of 110 per cent; the lungs receive less than 10 per cent of this dose. The entire treatment is completed in a period of from five to seven days or longer, depending on the physical condition of the patient. For the treatment, use 200,000 volts, 4 ma. of current, 0.5 mm. Cu + 1 mm. Al. Firm compression is used. The stomach is treated from three fields: one anterior, from right to left outward and upward; one lateral field on left side going straight through inward, and the third field posteriorly from right to left upward and outward. Holfelder has used this method for eight and one-half years, and has prolonged life in 50 per cent of his cases one year.

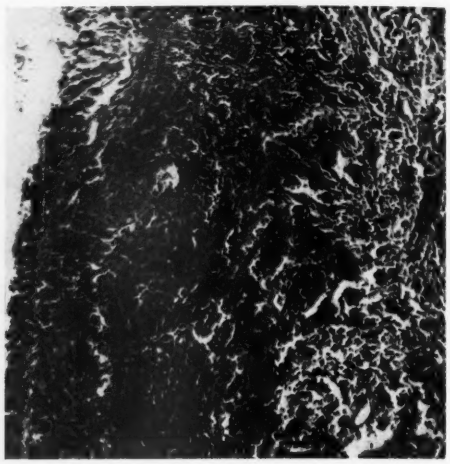

Fig. 4. Photomicrograph of tissue removed.

From seven to ten days after the final roentgen treatment, the saturation method is given, completed in two or three days. The saturation method, as described by Dr. Pfahler, indicates the greatest amount of radiation that can be tolerated by the surrounding normal tissues without damage being done to them. The saturation method depends upon the delivery into the diseased area of what we have learned to term "erythema dose" or "toleration dose," and then the retention of this effect for a certain time by additional smaller doses of radiations at intervals to correspond to the loss in effect during any period. The rate of loss, and the amount of radiation to be given at any interval, is indicated by a series of curves.

On Dec. 31, 1928, a re-examination of patient's stomach, after a barium suspension meal, shows that it is situated to the left of the median line; that greater and lesser curvatures are even in contour, and that the gastroenterostomy opening is functioning normally.

Twenty months after the operation, the patient weighs 135 pounds. He eats of everything, has no complaints, no pain, his bowels are normal, and there is no eructation after eating. Before operation, he weighed 119 pounds which has increased to 148 pounds, in May, 1929.

CONCLUSIONS

1. Tentative pre-operative diagnosis.
2. Laboratory tissue report on specimen resected at operation.

3. Technic of roentgen therapy.
4. Roentgen findings 1 year after deep roentgen therapy.

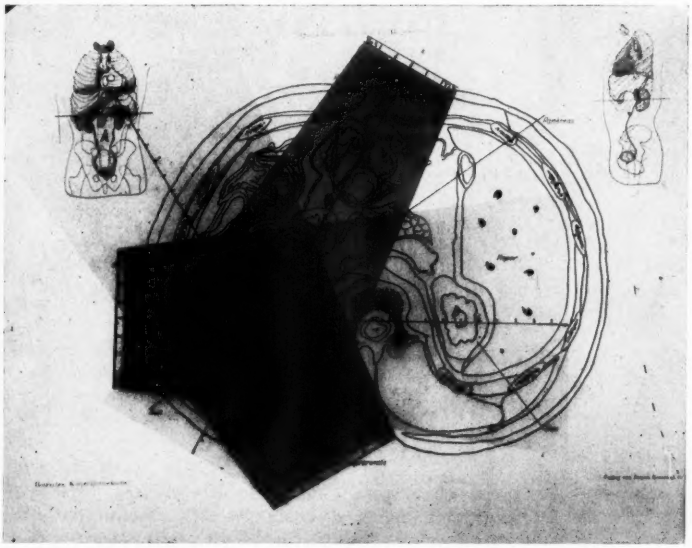

Fig. 5. Here is shown the field selectors, arranged in three fields across the section of stomach, as suggested by Holfelder.

5. Patient under observation April 15, 1931, and feels perfectly well.
6. Patient died from carcinoma of the liver, May, 1932.

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53 West 73rd St.

PELVIMETRY BY MEANS OF STEREOSCOPIC X-RAY PLATES[1]

By DOSTER BUCKNER, M.D., *Fort Wayne, Indiana*

For some time I have been interested in simplified pelvimetry which could be done in any x-ray laboratory possessing, in addition to the usual roentgenographic equipment, a common yardstick and a plumb-bob.

The method which I wish to report has nothing to do with formulæ or apparatus. A knowledge of geometry is a necessity, and when the underlying principles are understood, the desired diameters are easily, quickly, and accurately made. The only possibility of error is in inaccurately marking the points on the films from which measurements are to be made.

Distortion of anatomic parts has always been a bugbear to radiologists and also to those who view x-ray plates. I have always maintained that the x-ray apparatus is a machine of precision and that, if radiographs were properly made, correct interpretation could be made. So, in attempting this problem, I have tried to prove that we should not be skeptical of x-ray films, but should keep in mind that the negative is an exact duplication of what was directly before the film at the time of exposure.

I give this method as absolutely original. I have found no literature that suggests a simple method of constructing graphically the measurements of the pelvis. Therefore, the problem to be solved is to represent graphically the exact measurement or distance between

[1] For their collaboration in this article, I wish to thank Mr. A. W. Zimmerman, pioneer radiologic instructor, Miss Mildred Whitmer, mathematician, and Miss Lillian Gerard, draftsman.

two points in the body through the use of radiographs by a simple method.

Stereoscopic plates (using a Bucky diaphragm to make more distinct the points to be measured) are made of the pelvis, using a horizontal shift of 4 inches. The known distance from the target to the film has been set at 30 inches. A plumb-bob is attached to the center of the filter and the length of the cord allows the bob to hang just above the patient. Markers are placed on each end of the cassette carriers to show that each film is exactly in the same position.

After the films are dried, put a pin hole through each point on each film, including the plumb-bob shadows, from which distances are to be measured. Superimpose the films by means of the markers. Then fasten the films either by means of clamps, adhesive, or mucilage, or in any way that will keep them from slipping. Then repunch all holes through both films. By doing this, the pin goes through the old holes and makes a new spot on the other film. The films may either be kept together and measurements made, or separated. Place one of the films on a piece of white paper, hold firmly, and by means of a pen or pencil put dots through the holes on to the paper. After the desired points have been marked, you will have six dots for each diameter. Two of the dots represent the shadows of the plumb-bob in the two positions, and the other four dots represent both ends of the desired distance to be measured in the two positions of the target.

Of course, you will recognize that the plumb-bob shadows are the perpendicular projections of the target in its two positions. The distance between the two plumb-bob shadows represents the distance of the shift.

Now, draw two lines from each plumb-bob to the respective images that were made when the target was perpendicular to that plumb-bob shadow. These lines, four in number, are the perpendicular projections of the hypotenuses of four right-angle triangles. The perpendicular sides of all these triangles are 30 inches in height, and we also know that the planes of these triangles are perpendicular to the plane in which the film was placed when exposure was made.

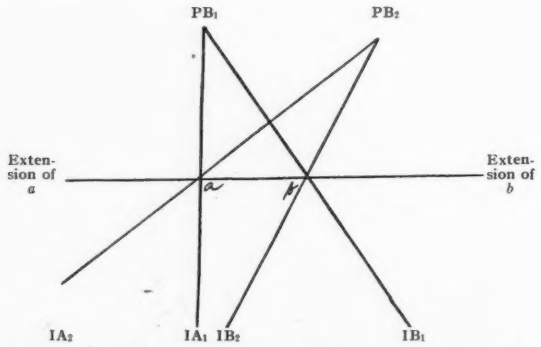

Fig. 1. The two plumb-bob shadows are PB_1 and PB_2. The drawing shows the two images of *a* and *b* when in two positions, respectively, at IA_1, IB_1, and IA_2, IB_2. It also shows the base lines of four right-angle triangles which intersect at *a* and *b*.

After the four lines are drawn (Fig. 1), it will be noted that the lines cross at points *a* and *b*. A line drawn from *a* to *b* represents the perpendicular projections of the desired diameter to be measured. A continuation of line *ab* is used as a base line to compute final calculation.

After we have the six points and the four lines drawn, and the line *ab* with its extensions, the diagram is transferred to a paper a few inches longer than the distance of the target from the film. In this case the target was 30 inches, so that the paper would need to be about 6 inches longer. The line *ab* is placed parallel with, and as near as possible to, the lower edge of the paper, allowing the image projections to be shown.

Study of Figure 1 shows a few obvious conclusions. Points PB_1 and PB_2 are the perpendicular projections of the target on the film. PB_1 and IA_1 is one side of the right-angle triangle, the plane of which is perpendicular to the plane of the film. Likewise, the four lines of the right-angle triangles are the perpendicular projections of the hypotenuses of those respective triangles. The points *a* and *b* are the projected points from which measurements are to be taken. Line *ab* is the perpendicular projection of the desired distance to be measured

We also observe that we have two pairs of triangles, paired in that their planes intersect. Using one pair of triangles and allowing one

Fig. 2. The base lines of the triangles are shown superimposing on base line *ab* after the pivoting of the base lines of the triangles, using *a* and *b* as centers of an arc.

triangle to swing clockwise and the other counterclockwise, using *a* or *b* as a pivot, we have their bases superimposing on base line *ab*. Likewise, the other pair of triangles is swung to the base line, and, using *a* or *b* as a pivot, we have a figure such as is illustrated in Figure 2.

Using the base line *ab*, designated as PB_1, PB_1, PB_2, PB_2, respectively, construct the perpendiculars 30 inches in height, or the normal distance of the target from the film. From these points draw lines to points IA_1, IB_1, IA_2, IB_2, respectively. It is understood that these last lines are the hypotenuses of their respective right-angle triangles (Fig. 3). A line drawn from the intersection of one pair of hypotenuses to the intersection of the other pair of hypotenuses is the distance to be measured.

This method is applicable to any desired measurement to be made. It is also helpful in localizing foreign bodies. The localization of any foreign body, the specific gravity of which is more than water, can be determined through radiographs by this method.

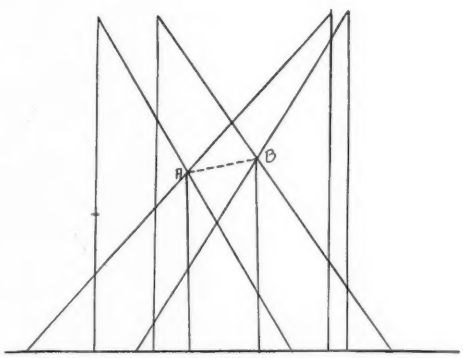

Fig. 3. Reconstruction of the four right-angle triangle's actual size on the plane of the film. The intersection of the two pairs of hypotenuses are the points from which measurements are to be taken.

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CHOLECYSTOGRAPHIC STUDY OF THE BILE DUCTS[1]

REPORT OF AN UNUSUAL CASE

By HAROLD SWANBERG, M.D., F.A.C.P.,
Quincy, Illinois

Cholecystographic examinations of a normal human being show the gall-bladder outline, frequently the cystic duct, and occasionally the common bile duct. I wish to present a case in which the roentgenograms show the entire biliary system, with the exception of the bile capillaries. In order to refresh the reader's memory concerning the biliary system, the anatomic study is briefly reviewed.

[1] Read before the Section of Radiology of the American Medical Association, at Milwaukee, Wisconsin, June 15, 1933.

BILIARY TRACT ANATOMY

The liver consists of two main lobes, the right and the left, each composed of small individual parts called lobules which are held together by extremely fine areolar tissue. The size of the lobules are from 1 to 2.5 mm. in diameter, and each lobule consists of a mass of cells called the hepatic cells which secrete the bile

The biliary ducts, which convey the bile, originate in the little passages in the liver cells which communicate with canaliculi, termed bile capillaries or inter-cellular biliary passages. These passages are merely small chan-

nels or spaces left between the contiguous surface of two cells or in the angle in which three or more liver cells meet. The channels thus formed radiate to the circumference of the lobule and open into the interlobular bile ducts which accompany the portal vein and the hepatic artery. These join like the twigs and branches of a tree to eventually form two large main biliary ducts, the right and left hepatic ducts,[2] nearly of equal size, and which issue from the liver at the porta hepatis, one from the right, the other from the left lobe.[3] These unite to form the hepatic duct, which passes downward and to the right, for three or four centimeters, where it is jointed at an acute angle by the cystic duct from the gall bladder and forms the common bile duct. The common bile duct is about seven centimeters long and normally about three millimeters in diameter. At the termination, it unites with the pancreatic duct and opens by a common orifice upon the summit of the duodenal papilla, situated on the medial side of the descending portion of the duodenum. The short tube, formed by the union of the two ducts, is dilated into the ampulla of Vater. The cystic duct, about three to four centimeters long, runs backward and to the left from the neck of the gall bladder to join the hepatic duct. The mucous membrane lining its interior is thrown into a series of from five to twelve crescentric folds, similar to those found in the neck of the gall bladder, which project into the duct in regular succession. These resemble in appearance a continuous spiral valve and are called the valves of Heister.

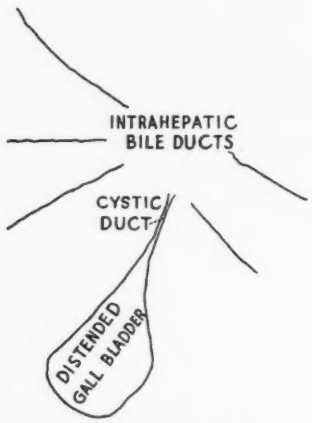

Fig. 1. Outline tracing of Figure 4.

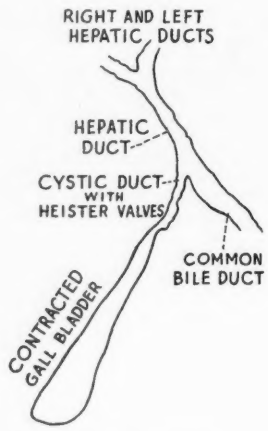

Fig. 2. Outline tracing of Figure 5.

SHERWOOD MOORE'S COMMENTS

Recently, following the oral administration of opaque dye to a patient, the entire biliary duct system was visualized with the exception of the bile capillaries. This observation appeared so unusual that the findings were communicated to Dr. Sherwood Moore, radiologic co-worker of Dr. Graham and Dr. Cole, discoverers of cholecystography. In a personal communication Moore stated:

"In reply, I would say that we have not visualized the ducts of the biliary tract in the course of a cholecystographic examination. We feel that by so doing the ducts would not have sufficient concentration of cholecystographic dyes to be made visible. Accounts of this have appeared in the literature from time to time, but these have not been convincing and none of them have been accompanied by illustrations, or at any rate illustrations that were plain enough to have left any impression upon my mind. We have always felt that visualization of the gall bladder is due to concentration of dye, and that the dye in the bile ducts was too diluted to be visualized. As a corollary to this we have considered that concentration occurred only in the gall bladder, though I believe the reason that the dye is visualized in the large intestines, as it is occasionally, is due to the fact that that structure takes up water and concentrates its contents. There is a well established contention that, in the absence of function of gall bladder either through removal or

[2] The right and left hepatic ducts, particularly the latter, are formed by the junction of the several smaller ducts.

[3] The bile, from the caudate and Spigelian lobes, enters the left hepatic duct.

disease, the ducts take on some, if not all, of its functions, among them being that of concentration of bile and hence concentration of cholecystographic dyes. In deference to such views we would consider that there might be, given the necessary conditions, a possibility of visualizing the ductal system of the biliary tract.

"I would say, having recently reviewed the literature, that you have a very valuable observation and I would urge you to report it. This, I believe, constitutes an important finding on the question of the ability of the duct portion of the biliary tract to concentrate the bile and is, therefore, an important point both in the physiology of the biliary tract and its compensating function, and has an important bearing on cholecystography."

In accordance with Moore's suggestion the following case is briefly reported.

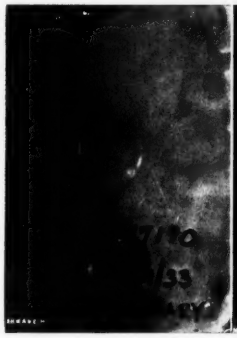

Fig. 3. Preliminary roentgen examination of the gall-bladder area, before the oral administration of dye for cholecystography. The findings were negative.

Fig. 4. One of the two roentgenograms made of the gall-bladder area 15 hours after the oral administration of dye.

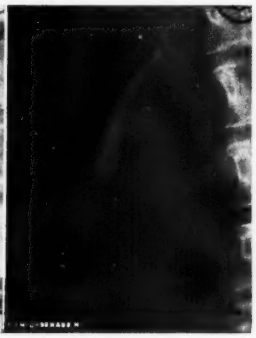

Fig. 5. One of the two roentgenograms made of the gall-bladder area one hour after taking a fatty meal, and 16 hours after the oral administration of the dye.

CASE REPORT

Mrs. F. K., aged 42 years, weight 117 pounds, suffering from dyspepsia, and on whom a thyroidectomy for hyperthyroidism had been performed some years ago, was referred by Dr. O. F. Shulian, of Quincy, Illinois, for roentgenologic study on Jan. 21, 1933. Among the examinations made was a cholecystographic study, a powder mixture of tetraiodophenolphthalein sodium salt in aqueous solution being given orally (immediately after a full meal, free from fats), in accordance with our usual technic. A preliminary examination of the gall-bladder area, before administration of the opaque dye, was negative. Fifteen hours later, the gall bladder was distinctly visualized, being normal in position, size, shape, and of uniform density. There were a number of opaque linear shadows, radiating like the spokes of a wheel, from the region of the under surface of the liver, corresponding to the porta, which we have interpreted as being some of the dye-filled intrahepatic bile ducts. These were constant in the two roentgenograms made at that time. Two hours later, and following a fatty meal, the intrahepatic bile ducts were no longer visible (a few very fine linear shadows remained), but the two large main biliary ducts were seen joining together to form the hepatic duct, this latter duct being clearly visualized. The gall bladder was now seen to be distinctly contracted, the cystic duct being visualized but somewhat irregular in contour because of the presence of the Heister valves. The union of the cystic and hepatic ducts was clearly outlined, forming the common bile duct, which could be traced for several centimeters. After the fatty meal, the findings were present in both roentgenograms taken at that time.

This examination was reported to be "a normal cholecystographic response," the unusual feature of the case being the visualization of nearly every part of the biliary tract by the oral administration of the opaque dye.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

WE MUST JOIN HANDS

We are witnessing to-day in America the spectacle of armed violence running riot through the land. This modern Robin Hood, many times more vicious than any previous one, threatens the very foundations of society. To meet it local forces has proved in vain; units of various kinds are ineffective. Not until there is concerted action, a unification of purpose, and a complete sacrifice of individualism in the interest of the whole, shall we see an end of such disastrous things.

Imagine, for a moment, an army fighting some national peril. Men are trained in the North; others in the South, East, and West. Some are prepared for land and others for sea fighting; some for the air, and others for trench work. But there comes a time when all must join hands, and under some central guidance work toward a prescribed goal. Should any unit or section refuse to obey orders, and selfishly decide upon separate action, we would see that its work would for the most part be lost and rendered ineffectual. The lack of concerted action would result in a loss to the entire nation, and present a stumbling lock to the ultimate goal.

There is a time in the history of all movements when union becomes necessary, if we would attain the best results. The life of the infant is lived within a very circumscribed area—and rightly so. There, in it, it may be protected, and encouraged, so that it may grow and finally reach maturity; and along with other infants it presently arrives at the stage when it may well emerge from its sheltered existence, and join the life of the larger group, and so make its fullest contribution to the life of the world. Its treasured individualism must be prepared to offer itself on the altar of society; to test its intrinsic values in a measure determined not only by its unique contribution, but in the way that it can be adapted for the good of the group as a whole—as part of something greater than itself. Men and their ideas, when clearly crystallized, must be ready to lose themselves in some central and controlling viewpoint, to be really effective. Isolated, they are utterly limited, but in concert with others they become triumphant.

It is with these thoughts in view that I consider our own branch of medicine. Our radiological societies have each had a unique place in the building up of our special work. To those pioneers who have never spared themselves in this cause, and in the making of our work what it is to-day, we shall be eternally grateful. But it is of the future that we must think, for this generation will pass on. How best can we secure and treasure for those ahead of us all that has been gained; and how can we organize most efficiently to attain the greatest good?

Let us join hands.

W. HERBERT MCGUFFIN, M.D.

ANNOUNCEMENTS

PERSONNEL OF THE PROGRAM COMMITTEE

NEXT ANNUAL MEETING

CHAIRMAN: W. H. McGuffin, M.D.

SUB-CHAIRMAN: L. J. Menville, M.D.

ADVISERS: G. E. Pfahler, M.D., B. H. Orndoff, M.D., A. U. Desjardins, M.D.

DIAGNOSIS: W. W. Wasson, M.D.

THERAPY: A. Soiland, M.D.

PHYSICS: Lauriston Taylor

CLINICS: J. T. Farrell, Jr., M.D.

SCIENTIFIC EXHIBITS COMMITTEE: P. F. Titterington, M.D., *Chairman*, R. A. Arens, M.D., B. R. Kirklin, M.D.

THE ANNUAL MEETING

SCIENTIFIC EXHIBITS

Progress has been made in preparation for the Scientific Exhibits display at the Twentieth Annual Meeting of the Radiological Society

of North America. Every effort is being made to assure complete success. The spacious, well appointed, and adequately lighted Italian Room at the Hotel Peabody, opening onto the mezzanine and convention floor, has been reserved for this purpose. The adjoining Florentine Room will be used by the Committee on Scientific Exhibits.

We are looking forward to having a number of interesting and instructive exhibits this year. Since our president, Dr. W. H. McGuffin, has conceived a rather intriguing and unique form of program, which includes clinics, it is to be expected that all members presenting clinics will have exhibits illustrating their respective subjects. All of the exhibits will be classified anatomically, and so arranged on the floor, with large placards indicating their positions. This procedure will facilitate ready location of those exhibits in which a member may be especially interested.

We solicit your co-operation in making this feature of our program a success by applying for space in the Scientific Exhibits to show interesting cases you may have in your files.

W. W. ROBINSON, M.D.,
Local Chairman,
Committee on Scientific Exhibits.

AMERICAN COLLEGE OF PHYSICIANS

The American College of Physicians will hold its Nineteenth Annual Clinical Session in Philadelphia, April 29–May 3, 1935.

Announcement of these dates is made particularly with a view not only of apprising physicians generally of the meeting, but also to prevent conflicting dates with other societies that are now arranging their 1935 meetings.

Dr. Jonathan C. Meakins, of Montreal, Que., is President of the American College of Physicians, and will arrange the Program of General Sessions. Dr. Alfred Stengel, Vice-president in Charge of Medical Affairs of the University of Pennsylvania, has been appointed General Chairman of local arrangements, and will be in charge of the Program of Clinics. Mr. E. R. Loveland, Executive Secretary, 133–135 S. 36th Street, Philadelphia, Pa., is in charge of general and business arrangements and may be addressed concerning any feature of the forthcoming Session.

EDITORIAL NOTICE

With the beginning of this, the twenty-third, volume of RADIOLOGY, plain Arabic figures are to be used in place of Roman numerals, as heretofore. This is done after a survey of the practice followed by other journals, and after consulting the preferences of excellent authorities. It is expected that it will further contribute to the usefulness of our Journal for its readers.

The Bulletin of the Indianapolis Better Business Bureau prints the following article, which connects up with the "Caution" published in RADIOLOGY, February, 1934, page 248.

MANY COMPLAINTS RECEIVED

AMERICAN CELLULOSE COMPANY,
1140 CONSOLIDATED BLDG.,
INDIANAPOLIS, IND.

The Better Business Bureau has received a large number of complaints from all over the country regarding the operations of this concern. These complaints come from doctors, x-ray laboratories, hospitals and others who have discarded x-ray and photographic film.

This company by means of literature and direct mail solicitations, purchases this discarded film for the purpose of reclaiming silver and other chemical constituents, which derivations are sold to other companies using them.

Complaints are all practically the same, to the effect that this company has offered to buy such film, that film has been sent in containers provided by this company, but that great difficulty is encountered in collecting.

Letters to the company are ignored. Mr. Louis R. Serinsky, who has operated this company for years, has refused to give any kind of a statement regarding the company.

LAY EDUCATION

Radiological diagnosis and treatment admirably lend themselves to publicity and when this is done it most naturally must be in accord with medical ethics and good taste. Statements of fact, at no time prejudicial to the interest of any other specialty, and emphasizing that much investment in apparatus and education is necessary to proper functioning, will inculcate in the minds of the public

points vital to radiologists. So educated, the public can accept, with sensible reconciliation, the exact status of the financial as well as the medical responsibility of the physician.

A notable effort along this line was made recently in Chicago in which members of the Chicago Roentgen Society were designated to co-operate with the Chicago Lighting Institute. The latter society sponsored a two weeks meeting dealing with various forms of light as it applies to illumination and irradiation of foods.

It was thought opportune to acquaint the lay people with the field of medical radiology, and an appropriate program was presented. Over three thousand persons attended these meetings and the enthusiasm of the audience warrants a yearly repetition of such a contact.

Radiologists should avail themselves of opportunities to talk before non-medical groups. It will make the public better able to judge real service and, consequently, provide the greatest weapon wherewith to defeat the shoddy service which is so prevalent to-day.

THE CLEVELAND MEETING

The Cleveland Meeting of the American Medical Association was very well attended, 339 radiologists registering in the Section on Radiology. It was the fifth largest registration of the sixteen present Sections. We believe that this attendance is remarkable when we remember that it is the youngest of all the Sections.

The Scientific Exhibit was one of the very finest in the history of the Association, and was particularly interesting because of the complete demonstration of the use to which the x-ray is now being put. A prominent member and officer of the American Medical Association stated that there were too many x-ray exhibits and that in the future the number should be reduced. It happened that the speaker himself had an interesting exhibit, which was illustrated by x-ray films. It would be a sad mistake to curtail the x-ray exhibit—the Scientific Exhibit would be the loser. When we realize that the x-ray is used in diagnosis and therapy in every branch of medicine, it is no wonder that it has attained a prominent place in the Scientific Exhibit.

At the first examination given by the American Board of Radiology on June 10, 11, and 12, 172 applicants were examined. A majority of these applicants were pioneers in radiology and many of them made the trip for the sole purpose of appearing before the Board in order to secure certificates. This response was most gratifying as it gave evidence of support by those men who have contributed so much to the speciality. A list of those who were granted certificates will be published shortly.

There are still approximately 150 applications from men who have not yet presented themselves for examination. Further examinations will be conducted in Pittsburgh on Sept. 22, 23, and 24, and in Memphis on Dec. 1, 2, and 3. It is urged that those who wish to come before the Board at Pittsburgh have their applications on file prior to August 1, and that those who desire examination at the session in Memphis forward their applications not later than September 1.

The Section on Radiology of the American Medical Association was well represented. Most interesting and educational papers were presented and discussed by America's foremost radiologists. All of the latest and most progressive thoughts in radiology were presented.

Three Resolutions of interest were introduced by Albert Soiland, M.D., and George M. Fisher, M.D., respectively. Dr. Soiland introduced the "Resolution Authorizing Section on Radiology to Invite Fifth International Congress of Radiology to be Held in America" and "Resolutions on Exploitation of Roentgenologists in Hospitals," while Dr. Fisher introduced the "Resolution Barring from the Practice of Radiology All Persons not Licensed to Practise Medicine."

The Fourth Conference of the American College of Radiology was presided over by H. K. Pancoast, M.D., the President. The guest speaker of the Conference was Ross V. Patterson, M.D., of Philadelphia, who is Dean of the Jefferson Medical College and President of the Association of American Medical Colleges. Fellows of the College who addressed the Conference were: B. R. Kirklin, M.D., Secretary of the American Board of Radiology; W. Edward Chamberlain, M.D., of the Commission on Radiological Education; Arthur C. Christie, M.D., of the Commission on Medical Economics; James T. Case, M.D., of the Commission on Public Instruction. The topic, "The Feasibility of Uniting the Scientific Organizations," was discussed during the Conference by the following: W. Herbert McGuf-

fin, M.D., President of the Radiological Society of North America; John T. Murphy, M.D., President of the American Roentgen Ray Society, and Rollin H. Stevens, M.D., President of the American Radium Society.

B. H. Nichols, M.D., of Cleveland, Ohio, was the most capable Director of the local arrangements.

MADAME CURIE

With inexpressible sorrow the world has just learned of the death of Madame Curie. Her loss to mankind will be keenly felt, for who else has been its greatest benefactor?

The radiological professions of all nations bow their heads in sorrow and respect to the memory of this noble woman, and with heavy hearts they mourn the passing of the greatest woman scientist the world has ever known. They will be consoled in the belief that she has joined the noble army of martyrs.

Madame Curie, as the world knows, was the discoverer of radium some thirty years ago. She was assisted in this work by her husband, Pierre Curie.

This epical discovery made Madame Curie the greatest woman scientist of this or any other era. We can recall but one other woman who approached Madame Curie in the field of science, and this was Caroline Leucretia Herschel, the astronomer.

Madame Curie was rewarded nobly for her wonderful discovery, not alone by her native Poland, but by all countries of the world. Among the many outstanding prizes which she won was the La Caze prize, the Albert and Davy medals. She was also twice the recipient of the Nobel science prizes. Perhaps the greatest tribute paid Madame Curie was by the women of the United States who presented her on the occasion of her visits to this country with a considerable amount of radium, purchased for her use.

Courtesy of the Journal of Chemical Education

The Late Mme. Curie

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APOPHYSITIS

Painful Heels Among Children (Apophysitis). Henry W. Meyerding and Walter G. Stuck. Jour. Am. Med. Assn., May 19, 1934, **102,** 1658–1660.

Beginning with Osgood's report in 1903, an important group of syndromes, accompanied by certain definite symptoms and by similar epiphyseal changes observed roentgenographically, have been described and elevated to the dignity of specific diseases. It has gradually become apparent that there are marked similarities in the general pattern of these diseases, for they all seem to follow trauma of one kind or another, occur generally in growing children, affect ununited epiphyses, and are very often accompanied by such characteristic roentgenographic evidence of changes in epiphyses as rarefaction, fragmentation, and, later on, abnormal calcification.

A seemingly uncommon type of this epiphyseal involvement is epiphysitis of the heel, or the so-called calcaneal apophysitis that is evidenced by painful heels and a limp among young, rapidly growing boys. To date, 40 of these cases have been reported. The heel is unique in being subject both to direct and to indirect trauma. In the Mayo Clinic, 22 cases have been seen. The average age of onset was 10.2 years; the ages ranged from 7.5 to 17 years. The treatment of this condition is palliative.

C. G. SUTHERLAND, M.D.

ARTHRITIS

Roentgen Therapy of Arthritis. Carl Fried. Strahlentherapie, 1934, **49,** 634–675.

The literature concerning roentgen therapy in the various types of arthritis is critically reviewed by the author who also reports cases of his own. In infectious arthritis, particularly of gonococcic origin, the results are often very striking (120 r is sufficient over the involved joint, a dose which should be repeated if necessary after 8 days). In gout, doses of from 140 to 180 r sometimes alleviate pain. The roentgen treatment of arthritis deformans is discussed at length. From 120 to 180 r heavily filtered radiation at intervals of from 3 days to 3 weeks is used by the majority of radiologists. The author first applies from 140 to 150 r, and then reduces the doses if an improvement is noted. Small joints receive less. The interval between treatments varies from 2 to 6 weeks. The mechanism of the effect of roentgen rays on the diseased joints is briefly discussed.

ERNST A. POHLE, M.D., Ph.D.

BIOLOGIC EFFECTS

Temperature and Biological Effect of Alpha Rays. F. Hercik. Strahlentherapie, 1934, **49,** 703–706.

The author exposed cultures of bacteria to alpha rays emitted by polonium at temperatures of 2.5, 3.5, 10, 23, 26, 35, and 36 degrees centigrade. The injury curves did not show any marked variation, and it seemed that the biologic effect of alpha rays was independent of the temperature in the cultures.

ERNST A. POHLE, M.D., Ph.D.

BONE DISEASES (DIAGNOSIS)

Suppurations of the Petrous Tip. Edmund P. Fowler. Jour. Am. Med. Assn., May 19, 1934, **102,** 1651–1655.

Suppurations of the temporal bone other than those in the middle ear, mastoid, and zygoma have been recognized more and more since 1904. Unilateral trigeminal pain is perhaps the most important symptom of petrositis. Gradenigo first described a syndrome of external rectus paralysis and trigeminal pain associated with a discharging ear. In reality, the term "petrositis," which means inflammation of the petrous portion of the temporal bone, should be used as a general diagnosis and should have as subheadings: (1) osteitis of the tip, *i.e.*, inflammation of the bone separating the air cells of a pneumatized tip; (2) osteomyelitis of the tip, *i.e.*, inflammation of the marrow and the bone of the tip, and (3) osteitis or osteomyelitis, as the case may be, of the perilabyrinthine regions.

Petrositis usually subsides spontaneously with adequate drainage from the middle ear. Inadequate drainage may result in a chronically discharging ear or meningitis and death.

C. G. SUTHERLAND, M.D.

Osteitis Tuberculosa Multiplex Cystica of Fibula and Tibia. Samuel Sanes and Warren S. Smith. Jour. Am. Med. Assn., April 14, 1934, **102,** 1206–1208.

This term is applied to cyst-like degeneration of the bones without joint involvement, characterized by the gradual onset of mild pain and swelling of the affected parts, distinctive roentgenographic features, and a chronic benign course. Not infrequently it is associated with lupus pernio and Boeck's sarcoid. Histologically, the bone showed epithelioid and giant-cell tubercles, with little or no caseation. Tubercle bacilli are rarely demonstrated in examined tissues; guinea-pig inoculations occasionally give positive results for tuberculosis. The lesions are restricted usually to the small bones of the hands and feet. The authors report the second example of the lesion involving the long bones. Roentgen examination revealed decreased density of bone tissue, with more or less oval excavation, which was cyst-like in appearance; there was a thickening of the periosteum on the outer side of this cyst-like excavation. The chest showed evidence of an old tuberculous lesion. The primary lesion was a tuberculous osteomyelitis, this present lesion being merely a late phase of chronic localized tuberculous osteomyelitis. Post-operatively two roentgen treatments were given to the leg.

C. G. SUTHERLAND, M.D.

Osteochondritis of the Patella, Including a Case with Multiple Epiphyseal Involvement. Moses Gellman. Jour. Bone and Joint Surg., January, 1934, **16**, 95–104.

In 1903 Osgood described a non-traumatic affection of the tibial tubercle, and in 1908 Köhler reported the first case of osteochondritis of the patella. Harbin and Zollinger classified the types of osteochondritis as primary or secondary, depending upon whether the primary or secondary centers of ossification were involved.

Buchman described osteochondritis as a "non-inflammatory, non-infectious derangement of the normal process of bony growth occurring at the various ossification centers at the time of their greatest developmental activity." Ossification of the patella commences at the age of five or six years and the primary type of osteochondritis is common at these ages when the center is growing rapidly. In rare cases the patella develops secondary centers of growth at about puberty. The involvement of these centers when they do appear results in secondary osteochondritis.

Various developmental anomalies, such as accessory centers of ossification, are often noted in the patella. These defects are bilateral in about two-thirds of the cases. These aberrant ossification centers, instead of fusing with the main body of the bone, may persist as separate centers at either pole. All components of the bone may be involved by osteochondritis. The quadriceps tendon above and the patellar tendon below may subject the patella to the irritative effects of severe traction. The osteochondral line of the lower femoral epiphysis, and the tibial tubercle may be involved, since these two sites are within the vulnerable area of this strong pull.

The author reports two cases of this condition, well illustrated by reproductions of roentgenograms. The first case occurred in a white boy, aged six, and therefore represents the primary form of osteochondritis. For several months the patient complained of tiring easily and occasional pain. The physical examination was essentially negative except for mild tenderness of the patellæ. Lateral roentgenograms revealed small, ragged patellæ with numerous areas of lessened density and incomplete ossification and a tendency to fragmentation at the lower poles. Rest in bed was prescribed. Two years and four months later, all tenderness had long since disappeared. Roentgenograms showed a nearly complete restitution of the bone structure in both patellæ. It was noted, however, that trabeculations were somewhat coarser than usual and that there were several sharp spiculations about the periphery at various points.

The second case, which was of the secondary form of osteochondritis, occurred in a white boy, aged twelve, who complained of pain in the right knee of one year duration. Physical examination revealed a small, smooth, rounded, tender, and slightly warm elevation on the outer pole of the right patella. The left patella was clinically negative. Roentgenograms of the right knee showed marked disorganization of the bony structure of the patella. There were also numerous areas of lessened density and incomplete ossification. The lateral view of the unaffected left side revealed an even more disorganized and "moth-eaten" patella. Irregularities were also discovered at the osteochondral borders of the lower epiphysis of each femur. After treatment for five and one-half months both knees were symptomless. Subsequently the patient complained of pain in the region of the tibial tubercles. About two years and four months later roentgenograms showed the right patella thickened and longer with an area of lessened density in its upper third. The left patella, except for appearing larger, had a normal internal structure. The fuzziness at the femoral epiphyses had disappeared.

J. N. Ané, M.D.

Bony Changes in Xanthoma Tuberosum Multiplex of the Hands. H. R. Schinz. Röntgenpraxis, January, 1934, **6** 22–25.

Xanthomatous nodes on the fingers and hands may destroy the bone by pressure or the deposits may take place primarily in the bone. The initial changes may clinically as well as roentgenologically be mistaken for gout. A case is described with multiple involvement of the bones of both hands. This disease belongs to the group of disturbances of the lipoid metabolism, as Gaucher's disease, Niemann-Pick's disease, and Schüller-Christian's syndrome.

Hans W. Hefke, M.D.

A Radiologic Contribution to the Recognition of Late Changes in Bone Following Trauma. Giuseppe Brancadora. Archivio di Radiologia, 1934, **10**, 72–77.

The author illustrates the findings in a case he studied to bring out some of the late sequelæ of injury, as shown by skeletal changes, which may be important both from a diagnostic and a medico-legal standpoint.

E. T. Leddy, M.D.

A Clinical and Radiologic Study of Cholesterol Lipoidosis of Christian-Schuller. Raffaello Liberti. Archivio di Radiologia, 1934, **10**, 13–49.

The author presents two cases of Christian-Schuller's disease, the pathologic anatomy and etiology of which he reviews in some detail. In the first case, a patient aged seven years, there was hydrocephalus, lesions in the ribs and radii, and some peculiar lesions in the femurs. In the second case, a patient aged 13 years, there were lesions in the skull, ribs, vertebræ, humeri, scapulas, pubes and femurs, joints, and soft parts. The author illustrates the findings by prints of radiographs and emphasizes the salient points in differential diagnosis.

E. T. Leddy, M.D.

BONE DISEASES (THERAPY)

Localized Focal Osteoporosis during Hypophyseal-ovarian Disturbance. Kurt Hatzky and Konrad Müller. Fortschr. a. d. Geb. d. Röntgenstr., 1934, **49**, 117–127.

Two cases are reported with a spotty porosis in the lower tibia and in the tarsal bones, which are assumed to be in etiologic connection to hypophyseal-ovarian dysfunction. Both improved under administration of calcium, phosphorus, and "Vigantol." The symptoms of these patients differed from those usually seen in similar endocrine disturbances and resembled more the osteoporosis of inactivity following injury (Sudek) or the symptom-complex described by Leriche.

HANS A. JARRE, M.D.

CONTRAST MEDIA

Perforation of an Esophageal Diverticulum into the Trachea. Ludwig Bayer. Röntgenpraxis, January, 1934, **6**, 31–34.

Communication between esophagus and trachea is caused by malignant growths in the greatest number of instances. In the case reported by the author the patient complained about pressure in the chest, cough, and temperature. During roentgenologic examination the barium entered a diverticulum about midway between pharynx and bifurcation; at the same moment a violent attack of coughing began and the barium was seen in the trachea and the bronchial tree. The patient died from a bronchopneumonia after a gastrotomy had been done. The author believes that barium should not be used in similar cases, but, rather, a small amount of iodized oil which might not be as liable to cause pneumonia.

HANS W. HEFKE, M.D.

DOSAGE

The Dositron. Siegmund Strauss. Strahlentherapie, 1934, **49**, 712–717.

The author describes a new type of measuring instrument equipped with a thimble ionization chamber and suitable for determining the r output of x-ray apparatus. While it is possible to measure the r per minute during the treatment, the instrument does not integrate the dose.

ERNST A. POHLE, M.D., Ph.D.

The Roentgentherapy of Malignant Tumors with Protracted-divided Doses. Carlo Guidotti and Desiderio Perotti. Archivio di Radiologia, 1934, **10**, 78–90.

The authors have treated 29 cases of cancer, with very satisfactory results. The technic is as follows: 170 K.V., 3 ma., 50 cm. T.S.D., 1.5 Cu + 2 Al in 50 sessions of 60 r each (giving about 3 r per minute).

E. T. LEDDY, M.D.

ELECTRICAL ACCIDENTS

The Peculiarities of Electrical Accidents. Stefan Jellinek. Röntgenpraxis, January, 1934, **6**, 1–12.

The electrical accident presents symptom-complexes which are clinically and pathologically often very peculiar. It is erroneous to believe that results of laboratory experiments on animals may be used as facts in the electropathology of humans. Many such experiments have been done in order to determine the voltage and amperage which is dangerous to life. It generally has been found that one-tenth of an ampere can be tolerated by human beings without fatal results. This theory, however, does not hold true in clinical medicine. Some persons exposed to many amperes remained alive and did not even become unconscious; others, who only touched a loose connection of a lamp and showed no external evidence of electrical injury, fell dead, and measurements done immediately showed a current of only a few milliamperes. It is impossible to state even approximately a certain minimum amount of electric current which is not dangerous to life. Certain other influences play an important rôle, as meteorologic conditions, the psychic complex of fear of death, or delayed and amateurish first aid. Experience teaches that a very short exposure may be just as dangerous as a prolonged one. Accidents with alternating current are more dangerous than with direct current. If one is guided by the results of animal experiments concerning the localization of the electrodes, one would again be wrong in the clinical application of the results. The case is quoted of a boy who died immediately after touching an electric wire carrying 110 volts; the current passed from the thigh through the foot into the ground. And yet a man through whose body a current of 380 volts passed from one hand to the other did not even become unconscious, although the accident must ordinarily be considered as absolutely fatal.

There are three somatic-psychic factors which determine the injury by an electric current: the resistance of the skin, the individual tolerance, and the mental condition at the time of the accident.

Wet skin is a much better conductor than a dry and calloused skin. That is illustrated by a fatal accident to an engineer with soft moist hands, who had touched an engine just previously touched by a laborer, with hard calloused hands, without any effect at all.

There is unquestionably a difference in individual tolerance. In certain accidents wherein two or more persons receive approximately the same amount of current, the individual effects may be entirely different.

One must also admit the existence of a psychic protective mechanism. An electrician may intentionally touch both poles of a line carrying 110 or 220 volts, for testing purposes, without receiving any harmful effects: at another time he may accidentally touch the same wire and may be severely injured or even killed. In the first instance his mind was prepared for the current; in the other, not. In the rescue of victims of electrical accidents it is the man with a

prepared mind who is not going to be injured, while the fear-stricken rescuer will probably be injured himself. Suicidal attempts by means of electricity are often not successful because the contact takes place with the mind prepared for it.

If death takes place it may be either immediate and synchronous with the electrical accident or it may be after a few seconds or even after an interval of hours. Cases have been reported in which the victims fell down unconscious, got up again without help, even talked about the accident, and then again collapsed after a few seconds or minutes and died this "interrupted death." Fairly often, instances of such "dead" persons having been revived have been recorded, even after having been declared dead by physicians. All depends on quick and correct measures. The Silvester method of artificial respiration is the only physiologic and efficient one with which the writer is familiar. It is wrong to quit after half an hour of unsuccessful attempts; even two hours is not long enough. The author has himself seen cases in which the method was successful only after three hours of continuous application. Only the appearance of postmortem lividity should mean death. A physician present at the scene of the accident should sometimes do a venesection and lumbar puncture—of course, not during the first minutes of artificial respiration, because there is danger of air embolism and because the latter is of more importance. Resort may be had to intracardial injection of adrenalin.

Electric burns are entirely without inflammatory reaction, and painless. A necrosis, taking place after weeks, is aseptic. Even very severe wounds, with injury to bones and joints, do not need radical surgical procedures. Strictly conservative measures are of the utmost importance. One must watch out for massive hemorrhage in the third or fourth week.

HANS W. HEFKE, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

The Roentgenologic Diagnosis of Perforation of Gallstones and Intestinal Obstruction Caused by Them. R. Kaiser. Röntgenpraxis, January, 1934, **6** 12–16.

The author observed the wandering of a perforated gallstone from the duodenal cap to the ileum, where it lodged. He was able to demonstrate on roentgenograms how the stone was first temporarily stopped in the duodenal cap and how it caused small intestinal obstruction a little later. At operation and autopsy the stone, the obstruction, and the fistula between gall bladder and duodenum were seen, also stones in the gall bladder. The latter were visualized on roentgenograms as negative shadows in a barium-filled gall bladder.

HANS W. HEFKE, M.D.

GRENZ RAYS

A New Integrating Measuring Instrument for Grenz and Light Rays. Siegmund Strauss. Strahlentherapie, 1934, **49**, 715–717.

An integrating dosimeter is described which has an ionization chamber for measuring grenz rays, and a special photoelectric cell to determine the output of ultra-violet lamps.

ERNST A. POHLE, M.D., Ph.D.

GYNECOLOGY AND OBSTETRICS

Relaxation of the Pelvic Joints in Pregnancy. Daniel Abramson, Sumner M. Roberts, and Philip D. Wilson. Surg., Gynec. and Obst., March, 1934, **58**, 595–613.

The question of the relaxation of the pelvic joints in pregnancy has excited considerable interest and much controversy since the announcement of the Hippocratic theory of "disjunctio pelvica." A large number of medical authors have written on the subject, expressing views which differed markedly, some believing that pelvic joint relaxation was a normal and constant phenomenon, and others that it was exceptional and pathological.

The authors compared measurements of the symphysis pubis obtained by means of the Johnson method of stereoroentgenometry with direct measurements on the film of the distance between the two pubic bones. The difference was found to be less than one millimeter, so all measurements were then made direct, adopting a fixed target-film distance of 30 inches. A control series of 123 non-pregnant females, comprising 33 nulliparæ, 20 uniparæ, and 70 multiparæ, was next chosen. It was found that the average measurement for the symphysis pubis in the nulliparæ was 4.09 millimeters, for the uniparæ 4.15 millimeters, and for the multiparæ 4.6 millimeters. In the nulliparæ these measurements varied from 3 to 6 millimeters, inclusively, while in the multiparæ the variation was from 1 to 8 millimeters, inclusively.

The difference noted between the appearance of the symphysis in the nulliparous and multiparous women is of considerable interest. In the former group the outline of the margins of the pubic bones was smooth, with only a thin cortical layer of increased density. In the multiparous group there appeared to be a definite tendency to greater irregularity of the pubic margins of the symphysis, with greater unevenness of the cortical outline. Occasionally small round areas of decreased density suggestive of cyst formation were noted. Age seemed to have little influence on the width of the symphysis.

X-ray measurements of the symphysis pubis were next done in a series of 71 males. The measurements obtained in this group were very similar to those obtained in the group of nulliparæ, as the variation noted was from 3 millimeters to 6 millimeters, with an aver-

age for the entire group of 4.4 millimeters. The pubic margins in this group were smooth and straight.

The first group of pregnant women studied consisted of 111 individuals who had been x-rayed during the last two months of pregnancy for the study of fetal measurements. A definite increase in the measurement of the symphysis pubis was noted. The average width was 7.7 millimeters and the measurements varied from 3 to 20 millimeters. The width of the symphysis was 9 millimeters in 24.3 per cent of this group.

The second group was chosen to study the effect of previous pregnancies in weakening the pelvic joints, and consisted of 25 primiparæ in their last two months of pregnancy. The measurement of the symphysis pubis in this group averaged 7.9 millimeters, with 28 per cent measuring 9 millimeters or over.

The third group comprised 93 observations on 38 individuals. Consecutive roentgenological measurements were made at different periods both antepartum and postpartum in this series of pregnant women. The results indicated that the process of relaxation began during the first half of pregnancy, and that the parturition seemed to have very little effect in increasing the width of the symphysis. It was also noted that retrogression of the symphyseal relaxation began in the first month postpartum and was fairly well complete by the end of from three to five months.

The authors also studied pubic mobility by making two films on each patient. One film was taken with a push on the right leg and a pull on the other, and the second film was exposed with the push and pull reversed. Comparison of films showed that the degree of pubic mobility varied with the amount of pubic separation, being greatest in those patients with the wide gaps.

The authors are of the opinion that the causative factor of the relaxation of the pubic joints in pregnancy is similar to that advanced by Hisaw, who isolated a hormone known as "relaxin," which he identified in the blood stream of guinea pigs, dogs, cats, sows, mares, and rabbits during pregnancy.

The symptoms usually noted in pregnant women referable to the pelvic joints consist of pain in the region of the symphysis, sensation of movements of the bones when walking, and pain and backache localized over one or both sacroiliac articulations. Examination usually reveals a waddling gait, and, on palpation, the separation may be noted and pain and tenderness elicited. Treatment is indicated to relieve symptoms and to prevent the development of chronic relaxation of the pelvic joints.

J. N. Ané, M.D.

INFLAMMATORY DISEASES

The Principles of Roentgentherapy in Inflammatory Disease, Otto Dyes. Strahlentherapie, 1933, **47** 160–178.

The author presents a critical review of the principles and assumptions underlying the use of roentgen rays in inflammatory disease. A very complete bibliography (6 pages in small type) is appended.

Ernst A. Pohle, M.D., Ph.D.

JOINTS

A Case of Chondromatosis of the Shoulder Joint. Aladar V. Szigethy. Röntgenpraxis, January, 1934, **6**, 28–31.

Chondromatosis of joints is usually seen in only one joint, most frequently in the knee, elbow, or hip joint. It has been observed in shoulder and ankle joints only very rarely. The author describes a case of chondromatosis in the shoulder joint in a man 51 years old, who had suffered an injury to this joint a few years before the clinical symptoms began. The secondary inflammatory changes in the joint were benefited by small doses of roentgentherapy.

Hans W. Hefke, M.D.

A Study of 100 Cases of Subdeltoid Bursitis. Mark H. Rogers. Jour. Bone and Joint Surg., January, 1934, **16**, 145–150.

The author discusses the anatomy of the subdeltoid bursa and related structures, the classification and the relation of subdeltoid bursitis to trauma and infection. The supraspinatus muscle arises from the scapula and is attached to the humerus in the same area as the capsule of the joint. This muscle after it becomes spread out lies just above the joint capsule and beneath the floor of the subdeltoid bursa. The bursa is a thin-walled structure lying just beneath the deltoid muscle.

Calcified areas are shown by x-ray examination in the acute and sometimes in the chronic cases of subdeltoid bursitis. These areas are situated on the superior surface of the joint capsule and supraspinatus tendon. They are not within the bursal sac, but the posterior wall of the bursa lies on top of the calcification, which is believed to be essentially a calcium carbonate.

The author groups the cases of his series into three classes: (1) the acute, fulminating type; (2) the chronic, adhesive type, and (3) the traumatic type. The acute type is of sudden onset and reaches its greatest intensity in from three to four days. The chronic, adhesive type is of slower onset and presents a different clinical picture from the first group. In the chronic type, there is no acute pain unless the arm is moved. The traumatic type follows a history of a fall or a twist of the arm.

The average age of the 29 cases of the acute fulminating type was 48 years. The group of chronic cases consisted of 46 cases with an average age of 56 years. Twenty-five cases made up the traumatic group with an average age of 55 years. In this series no case of subdeltoid bursitis was found in a patient under 30 years of age.

The author also studied the relation of focal infection to subdeltoid bursitis and failed to find any evidence that the condition of the shoulder resulted from infection. Of interest, however, was the high incidence of diabetes in the group of chronic cases, in which 18 patients were diabetics.

J. N. Ané, M.D.

LIGHT THERAPY

Modern Finsen Treatment. Svend Lomholt. Strahlentherapie, January, 1934, **49,** 1–64.

On 64 pages, the director of the skin clinic of the Finsen Institute, in Copenhagen, outlines the indications for and the results to be expected from Finsen light therapy. The article does not lend itself to abstracting, and is recommended for study in the original. One observation of interest to the radiologist may be mentioned, that x-ray late reactions, *i.e.*, atrophy, telangiectasis, ulcers, are often benefited by proper Finsen treatment.

Ernst A. Pohle, M.D., Ph.D.

NEURALGIA

The Physical Methods of Treating Neuralgias. G. Cola. Arch. di Radiologia, 1933, **11,** Fasc. 3, pp. 560–578.

Seventy-three cases of neuralgia (33 sciatic, 16 trigeminal, 11 brachial plexus, 9 intercostal, 2 femoral, and 2 occipital), treated by various combinations of the physical agents, are reported by Cola. In general, he gives roentgentherapy first place in the treatment of these painful disorders and he reviews some of the theories which have been advanced to explain the analgesic action of x-rays.

E. T. Leddy, M.D.

THE OVARIES

The Biology of the Irradiated Ovaries: Dermoid in the Ovary of a Woman Treated by Radium for Carcinoma of the Cervix. Joachim Granzow. Strahlentherapie, 1934, **49,** 694–702.

A woman, 41 years of age, had a carcinoma of the cervix (Group 3). She was treated by intratuterine radium application, followed by deep x-ray therapy to the pelvis. Amenorrhea promptly occurred, and 27 months after radiation therapy the patient was clinically free from all cancer symptoms. Five months after the last examination, in other words 2 years and 8 months after the treatment, a tumor of fist size was found in the left ovary which, after having been removed, showed, histologically, a typical benign dermoid cyst. The other ovary revealed the typical picture found following roentgen sterilization. There was no evidence of carcinoma in the uterus or the cervix. The author concludes from this observation that amenorrhea after irradiation is no proof for the anatomic or biologic elimination of the ovaries.

Ernst A. Pohle, M.D., Ph.D.

OXYGEN PNEUMOPERITONEUM

Oxygen Pneumoperitoneum in the Diagnosis and Treatment of Tuberculosis of the Genitalia, Intestine, and Peritoneum. Irving F. Stein. Surg., Gynec. and Obst., March, 1934, **58,** 567–577.

The author discusses the value of oxygen pneumoperitoneum in the diagnosis and treatment of tuberculous peritonitis, cites 64 cases from the literature, and reports six additional ones. In 1872, Spencer Wells operated upon a woman for ovarian cyst but found, instead, tuberculous peritonitis. A cure followed the opening and closing of the abdomen. Wells, however, did not appreciate the significance of this result, and the surgical treatment of tuberculous peritonitis became a recognized procedure only after Koenig advocated it in 1884.

Hertzler has pointed out there are about twenty theories advanced to explain how simple laparotomy cures tuberculosis of the peritoneum. Lauenstein believed that the removal of fluid and exposure to light resulted in the cures reported. Norris held that the removal of fluid alone was responsible for the good results obtained. Sterilized air, filtered air, atmospheric air, nitrogen and oxygen all have been employed in the treatment of tuberculous peritonitis, with good results. The author is of the opinion that the inflation of the abdomen with from 100 c.c. to 1,000 c.c. of oxygen by the puncture method should replace the surgical exploration.

The diagnosis of tuberculous salpingitis is considered difficult, although it may be suspected after a careful study of the patient's history and results of bimanual and abdominal examinations. This condition is responsible in from 5 to 10 per cent of inflammatory lesions of the fallopian tubes, and is a common cause of salpingitis in the virgin. By means of diagnostic pneumoperitoneum, alterations in the size, shape, density, and relationship of the various pelvic organs, and especially the presence or absence of adhesions may be demonstrated clearly in the x-ray film.

The preparation of the patient for this procedure consists in emptying the bowels by means of a cleansing enema about an hour before treatment. One-half hour before treatment morphine sulphate alone or with scopolamine hydrobromide should be administered. The bladder should be emptied just before treatment. The skin of the lower abdomen is prepared by alcohol, followed by 2 per cent mercurochrome solution. A firm, inflexible needle 3 inches in length, fitted with a stylette, is employed for the puncture, without local anesthesia. A point one inch to the left and slightly below the umbilicus should be selected for the puncture. If fluid is present, about one liter may be removed by trocar, and the trocar used for the insufflation. The author employs the apparatus used for the Rubin patency test, substituting an oxygen tank for that of carbon dioxide. If a needle is employed, no dressing is required. The patient should be kept flat, both on the x-ray table and during transportation, to avoid "shoulder pain" caused by gas entering the right sub-

diaphragmatic space. Within 48 hours all signs of oxygen have usually disappeared and the procedure may be repeated at this time if indicated. In some of his cases the author combined the use of oxygen pneumoperitoneum with uterosalpingography.

The following conditions are recognized as contra-indications to this procedure: Moribund patients; the plastic form of tuberculosis; grave pulmonary tuberculosis; advanced ulcerative intestinal tuberculosis. Pregnancy is regarded by some as a contra-indication but the author is of the opinion that during the first three months, when the uterus is not likely to be traumatized by puncture, this procedure may be safely used.

J. N. Ané, M.D.

PARATHYROIDISM

Hyperparathyroidism: A Common and Polymorphic Condition as Illustrated by Seventeen Proved Cases from One Clinic. Fuller Albright, Joseph C. Aub, and Walter Bauer. Jour. Am. Med. Assn., April 21, 1934, **102,** 1276–1287.

Seventeen cases are reviewed; a parathyroid tumor was removed in each instance. The disease is usually due to a functioning adenoma of the parathyroid glands, increased production of the hormone, a disturbance in the metabolism of calcium and phosphorus. The easily measurable manifestations of this disturbance are an increased serum calcium level, a decreased serum phosphorus level, and an increased excretion of both elements in the urine, demineralization of the bones, multiple cysts, and benign tumors of bone tissue with giant cells. Clinical types are: Classic hyperparathyroidism; osteoporotic hyperparathyroidism; hyperparathyroidism with nephrolithiasis; hyperparathyroidism with renal insufficiency; acute perathyroid poisoning, and hyperpara hyroidism simulating (or complicated by) Paget's disease. In the majority of cases the disease smolders on for years, crippling but not killing. Fatal issue is usually from renal involvement.

There may be no skeletal changes demonstrable by x-rays. Demineralization must involve the entire skeleton, if at all. Urinary calculi or punctate deposits of calcium in the kidney parenchyma should be looked for in cases of questionable hyperparathyroidism. Fluoroscopy and roentgenography of the anterior mediastinum may aid in the localization of a parathyroid tumor.

Failure to make the diagnosis is regrettable in that therapy for it is highly successful.

C. G. Sutherland, M.D.

PARONYCHIA (THERAPY)

X-ray Therapy of Paronychia. W. Jessen. Strahlentherapie, November, 1933, **48,** 599, 600.

The author recommends the treatment of paronychia by x-rays. He gives 30 per cent H.E.D., filtered through 4 mm. Al, in one sitting, to be repeated if necessary after ten days. The results were, in his experience, most excellent.

Ernst A. Pohle, M.D., Ph.D.

PAROTITIS

Parotitis and Roentgen Therapy. E. N. v. Oettingen. Strahlentherapie, 1933, **46,** 651–654.

The author treated 25 cases of parotitis with roentgen rays, applying 25 per cent H.E.D. about two or three times. The results were entirely unsatisfactory. As a possible explanation he offers the fact that his patients were mostly post-operative surgical cases.

Ernst A. Pohle, M.D., Ph.D.

THE PATELLA

A Radiologic Study of the Normal and Pathologic Patella. Bona Raviola. Archivio di Radiologia, 1933, **11** No. 4, pp. 751–776.

The author discusses the normal patella and then describes the lesions found among 74 cases of pathologic patellas, the most important of which are illustrated by radiographs.

E. T. Leddy, M.D.

RADIOLOGY, PRACTICE OF

Radiodiagnosis in Clinical Medicine. Editorial, Brit. Med. Jour., April 7, 1934, No. 3822, 627, 628.

Since the discovery of the roentgen rays, or x-rays, by Roentgen, their use has extended into many departments of science, but their application to medicine has probably been the most fruitful of all. The first use of the roentgen rays in medical science consisted of the study of the skeleton and the search for foreign bodies. In 1896, Bouchard first made use of the natural transparency of the lungs compared with the shadows of the heart and skeleton, and thus initiated chest radiography. Then followed the introduction of the various contrast media, such as bismuth and barium salts, lipiodol, and opaque dyes for gall-bladder and kidney examinations.

The field of roentgenology has become so broadened and the need for special study and training in the accurate interpretation of the roentgenograms so important that a special branch of medical practice has arisen. It must be remembered that while we may feel competent to express an opinion on an ordinary photograph of a scene or person, the accurate interpretation of the roentgen film is different for it represents shadows of a three-dimensional world imposed on a two-dimensional plane. Béclère said, "The x-rays are never mistaken. It is we who make the mistake of demanding from them more than they can give or of interpreting their language wrongly." It is therefore necessary for one to

have a thorough knowledge of anatomy and pathology, and sufficient training and experience in normal and abnormal appearances of roentgen anatomy. No interpretation should be attempted without considering the history, and physical and clinical laboratory examinations of the patient. Consultation between the roentgenologist and the practitioner in charge of the case is very valuable. The practitioner should not only be a clinician of experience, but must have some knowledge of radiodiagnosis.

The demand for information and instructions in roentgenology is shown by the appearance of text-books and manuals devoted to various aspects of radiological practice. In the author's opinion one of the most recent and most satisfactory of the text-books written to instruct the clinician is the manual of radiodiagnosis written by Dr. Ledoux-Lebard, of the radiological clinic in the Paris Faculty of Medicine.

J. N. ANÉ M.D.

ROENTGEN RAYS IN INDUSTRY

The X-ray in the Study of the Catgut Ligature. Paul F. Ziegler and George L. Clark. Surg., Gynec. and Obst., March, 1934, **58** 578–589.

The authors studied the structure of catgut ligature under various conditions by means of the x-ray diffraction method. The x-ray wave lengths employed were 1/6000 as long as yellow light and x-rays and light are diffracted by suitable gratings. Crystalline substances serve as three-dimensional diffraction gratings for the x-ray because the atoms and molecules lie upon parallel planes which are spaced apart at distances comparable with the x-ray wave lengths. The diffraction pattern obtained for any crystalline substance depends on the arrangement of the ultimate structural units characteristic of the substance in question. The importance of such a study is: The determination of the basis for selection of raw catgut material; the selection of suitable technics for the alteration of structure from a less preferred to a more preferred orientation, and the possession of more exact knowledge of the mechanism of chromicizing.

It was previously determined by means of the x-ray diffraction method that ramie fibers, which represent one of the varieties of cellulose, are built up from a great number of very small crystal units, called crystallites or colloidal micelles, which are so arranged in space that a common direction in them is parallel to the axis of the fiber. This represents a high degree of preferred orientation. Cellophane, another variety of cellulose, on the other hand, is made up of these same little cellulose crystallites arranged at random. Cotton was found to represent an intermediate state of arrangement of these small units.

The authors found that raw catgut had a higher degree of preferred orientation than catgut which had undergone further processing, provided that tension and stretching were not applied during processing, for elevated temperatures and swelling disarranged the micellar arrangement. It was shown also that different samples of catgut from different manufacturers showed considerable variation in structure. It was reasoned also that catgut fibers which were rendered plastic by preliminary swelling could be pulled by suitable tension so that the micelles would be placed in more perfect alignment. The x-ray diffraction patterns obtained by these experiments proved this to be the case.

Since the more perfectly oriented catgut fibers are stronger in general than those with less preferable alignment of micelles, the x-ray diffraction pattern also indicates tensile strength. It is likewise known that tensile strength increases with gauge or diameter. The authors, therefore, studied the effect of increasing the ratio of strength to gauge by decreasing the gauge without changing the tensile strength. A number of strands of raw catgut were wetted and one-half of each original strand was then allowed to dry under tension. The other halves served for comparison. This experiment showed a marked increase in strength per unit gauge for gut dried under tension. This experiment was repeated, using catgut which had been subjected to high temperature and which had been stored in 98 per cent alcoholic solution and the results were the same. It is known that ligatures near knots remain after other portions are digested. X-ray patterns showed that at knots an improved preferred orientation is produced by the tension exerted.

J. N. ANÉ, M.D.

THE SPINE

Bacillus Proteus Osteomyelitis of the Spine. Seth Selig. Jour. Bone and Joint Surg., January, 1934, **16**, 189–192.

The author reports the case of a male, aged 37, who was admitted for hospitalization with symptoms of left ureter colic. Roentgenographic examination revealed a shadow in the course of the left ureter, and at cystoscopic examination an obstruction of the left ureter was noted. Six days after the cystoscopy, the patient had a chill and a rise of temperature to 105 degrees. Blood culture showed *Bacillus proteus*. The patient had six chills and later passed a calcium oxalate stone and all symptoms ceased.

Pain in the back of the neck was noted by the patient on the day of his discharge from the hospital. This increased in severity and about a week later he was readmitted to the hospital. At this time there was noted marked restriction of motion of the cervical spine in all directions. The temperature was 103.5 degrees and the patient complained of tenderness over the fourth to the seventh cervical vertebræ. Blood cultures and cultures of the urine were positive for *Bacillus proteus*. Roentgenographic examination revealed a definite narrowing of the intervertebral space between the fifth and sixth cervical vertebræ.

The treatment of this condition consisted of the application of traction by means of the Crile traction

apparatus. The pain was relieved and the temperature fell to normal. About five weeks later roentgenograms revealed an osteomyelitis of the fifth and sixth cervical vertebræ with collapse of both bodies. Treatment was continued by plaster spica and subsequently by a jury-mast attachment. Roentgenographic examination four and one-half months later showed bony fusion of the fifth and sixth cervical vertebræ.

J. N. ANÉ, M.D.

An Atypical Case of Tuberculosis of the Spine. Charles K. Petter and J. P. Medelman. Jour. Am. Med. Assn., April 28, 1934, **102,** 1378, 1379.

This is a case report of a female, aged 50, who had tuberculosis of the left knee in 1909 and of the left elbow in 1912. In 1921 a laparotomy was performed and tuberculosis of the right ovary, appendix, and peritoneum was found. Later, in 1921, the patient had pleurisy with effusion on the left side and went to a sanatorium for two years. In January, 1927, a large gland appeared in the left groin and a few days later an abscess pointing in this region was aspirated. In November, 1931, she entered Glen Lake Sanatorium with a mass in the left lumbar region, a discharging left ear, and cervical adenitis. There had been a weight loss of 25 pounds and progressive weakness over a two-year period.

Roentgenographic examination showed rounded areas of bone destruction in the eleventh and twelfth dorsal and first and second lumbar vertebræ. The left sacro-iliac was involved by a destructive process. The patient died in June, 1932, and the anatomic diagnosis was: (1) tuberculous spondylitis; (2) tuberculous peritonitis; (3) tuberculous lymphadenitis; (4) left psoas abscess; (5) pleural adhesions; (6) pericardial adhesions. Actinomycosis and metastatic carcinoma were considered from the roentgen appearances.

C. G. SUTHERLAND, M.D.

Delayed Appearance of Deformity in Vertebral Body Fractures. O. O. Feaster. Jour. Am. Med. Assn., Feb. 24, 1934, **102,** 598, 599.

The author has observed three cases in which, following comparatively mild forms of trauma, there have been fractures of vertebræ, not demonstrable in roentgenograms made shortly after the injury but which were seen in roentgenograms made within the following three weeks. In such cases, in which discomfort or disability persists, re-examination is requested. The lesion has been found from five to seven vertebræ above the site of pain. The lateral view of the bodies is usually the only film of definite value.

CHARLES G. SUTHERLAND, M.D.

SPLEEN

The Effect of Roentgen Irradiation of the Spleen on the Iron Metabolism in the Animal Organism. J. J. Arkussky. Strahlentherapie, 1934, **49,** 455–462.

The spleen of rabbits was exposed to roentgen rays with the following technic: K.V. not stated, 0.4 mm. Cu, 6 × 8 cm. field, 26 min. (710 r). The metabolism was carefully controlled before and after the exposure. Second and third treatments were given at certain intervals. It appeared that the application of high doses to the spleen as well as removal of the spleen reduced the excretion of iron. The liver apparently plays an important rôle in the deposition of iron, as proved by histologic studies.

ERNST A. POHLE, M.D., Ph.D.

THORAX

Simultaneous, Bilateral Spontaneous Pneumothorax: Report of a Case, with a Brief Discussion of the Literature. D. E. Markson and Warren Johnson. Jour. Am. Med. Assn., March 17, 1934, **102,** 826–828.

Bilateral spontaneous pneumothorax, occurring in the apparently healthy, is an extremely rare disease. McMahon found less than 50 cases reported from all causes.

The authors report a case occurring in an apparently healthy young man within a few hours after the onset. Within 24 hours after pitching a baseball game he noticed a severe lumbar pain, which persisted, and, in the course of an hour, was accompanied by dyspnea which became rapidly more intense. Fluoroscopic examination about six hours after the onset showed the right lung to be almost completely collapsed and the left about 50 per cent. Three thousand c.c. of air were removed from the right and 2,000 from the left side. The patient immediately began to breathe easier, his color changed to normal hue, and he slept comfortably in a fully recumbent position.

Very little is known about the supposedly ideopathic types of spontaneous pneumothorax. Kjaergaard, reviewing all available material, concluded that ruptured valve vesicle cysts, due to scar tissue, emphysema, or congenital malformation of the lung tissue, accounts for the cause in many cases of this disease. He suggested congenital disposition to valve vesicle. He cited cases in which a spontaneous pneumothorax simplex developed in more than one member of the family. In the case here reported, the history of the sudden suffocation of a maternal uncle, together with roentgenologic evidence of a left apical cyst, pointed to a congenital cyst as the possible etiologic factor. Emphysema is a rare cause. Traumatic bilateral cases sometimes run a benign course. Benign cases of spontaneous pneumothorax have been reported as occurring in tuberculosis patients. It is probable in such cases a valve vesicle may have been the cause, the tuberculosis playing no rôle whatever.

CHARLES G. SUTHERLAND, M.D.

Some Disorders of the Esophagus. Arthur F. Hurst. Jour. Am. Med. Assn., Feb. 24, 1934, **102,** 582–587.

The author discusses four esophageal syndromes: *The dysphagia of anemic women, achalasia of the cardiac sphincter (so-called cardiospasm), chronic peptic ulcer of the esophagus,* and *the recurrent hiatus hernia syndrome of von Bergmann.*

In the first of these conditions, the anemia is always of the hypochromic microcytic type, and it is generally associated with achlorhydria or hypochlorhydria. The condition occurs only in middle-aged women and is regarded as a complication of simple achlorhydric anemia. Atrophic glossitis is constantly present. The dysphagia is the result of disturbance in the neuromuscular mechanism, apparently the result of the atrophic inflammation of the mucous membrane in the neighborhood. Either the nerve endings are atrophied and fail to convey the afferent impulses, which results in the reflex relaxation of the sphincter, or the ganglion cells of Auerbach's plexus are involved and fail to convey the efferent impulse to the sphincter.

In *achalasia of the cardiac sphincter (so-called cardiospasm),* obstruction is caused by absence of the relaxation of the sphincter which normally occurs when, in the act of swallowing, a peristaltic wave reaches it. This is the result of organic disease of Auerbach's plexus, the only well-established example of a localized disease of the autonomic nervous system.

Peptic ulcer of the esophagus is generally regarded as a very rare condition. Discomfort and pain occur under the lower extremity of the sternum while solid food is being eaten and, less frequently, half an hour or more after meals. It often radiates to the back. At first it lasts for only a few minutes and is relieved by alkalis, but later it is prolonged and followed by regurgitation, so that the patient often becomes afraid to eat. Hematemesis, which may be severe and fatal, is a common complication, but perforation into the mediastinum, pericardium, or peritoneum is the usual cause of death. A fibrous stricture may develop and lead to more or less complete obstruction.

In *the recurrent hiatus hernia syndrome of von Bergmann,* in contrast with the familiar type of nontraumatic diaphragmatic hernia, which results from congenital shortness of the esophagus, the esophagus is of normal length. The tissues that surround it as it passes through the hiatus esophagus must be abnormally lax. This may sometimes be congenital but the greatly increased frequency in elderly persons suggests that it is mainly due to senile changes in the tissues. The hernia is generally intermittent, but it may become fixed and permanent. A case can be most successfully demonstrated when the patient drinks the barium suspension while lying flat on the back.

CHARLES G. SUTHERLAND, M.D.

Pulmonary Moniliasis. Henry J. Bakst, J. Beach Hazard, and John A. Foley. Jour. Am. Med. Assn., April 14, 1934, **102,** 1208–1213.

Bronchopulmonary moniliasis has been reported from practically all parts of the world. The maximum incidence is found in warm, moist climates; chiefly in adult life, and more often in males. The association of the infection with chronic debilitating diseases has often been noted. The organisms have been found frequently as secondary invaders in pulmonary tuberculosis and in neoplasms of the lung. Primary infection in man is generally attributed to direct contact or inhalation. The classification into types is based chiefly on the severity of the infection. The acute case may have a sudden onset, with a rapid progression to a fatal termination. The chronic case is usually insidious in onset and tends to follow a protracted course, with frequent remissions and exacerbations.

Roentgentherapy is reported to be of considerable benefit. Potassium iodide in large doses, thymol by mouth, gentian violet and methylene blue intravenously have been used with fair results.

C. G. SUTHERLAND, M.D.

Advantageous Use of Filters over Parts of Roentgenograms, Especially in Chest Exposures. A. Determann. Fortschr. a. d. Geb. d. Röntgenstr., 1934, **49,** 170–175.

To obtain optimal roentgenographic quality in spite of pronounced difference in density, for instance, good quality in both lung-fields in the presence of unilateral dense pleuropulmonary shadows, thoracoplasty, etc., it is proposed to increase the exposure by from 30 to 50 per cent so as to properly penetrate the dense side and to shield simultaneously the transparent side by interposition of a filter of from 0.05 to 0.1 mm. Cu between patient and cassette.

HANS A. JARRE, M.D.

Etiology, Development, and Significance of Pleural Calcifications and Ossifications. Klaus Kuhlmann. Fortschr. a. d. Geb. d. Röntgenstr., 1934, **49,** 147–154.

Pleural calcifications and ossifications develop at times as sequelæ to hemothorax, pleural empyema—at times of tuberculous etiology—but also following the common non-tuberculous types of exudative pleurisy. A minimum calcium content and an acid reaction of tissues, as exists when necrotic material is in contact with healthy tissue, must be present to permit development of young connective tissue, which later on may respond to certain stimuli. These conditions are reviewed briefly and a few cases are reported.

HANS A. JARRE, M.D.

Atypical Forms of Dry Pleurisy: A Radiologic and Clinical Study. Samuel Brown. Jour. Am. Med. Assn., Jan. 20, 1934, **102,** 193–196.

Certain atypical forms of pleurisy, namely, the interlobar, the mediastinal, the paravertebral, and the diaphragmatic, may best be recognized by the radiologic method. Studies in both the anteroposterior and

the lateral positions enable one to localize any abnormal shadow in the lung-field and determine its exact relationship to the interlobar fissures, the mediastinal structures, the spine, and the diaphragm. Thickening of the interlobar pleura in the horizontal fissure is more readily recognized in the anteroposterior position; that of the interlobar pleura of the oblique fissures is more readily recognized in the lateral position of the chest.

In acute or subacute dry pleurisy involving the outer lobar pleura, the mediastinal pleura, or the paravertebral pleura, pain is seldom present. An annoying, dry cough may be the most troublesome symptom. Physical examination of the chest rarely reveals anything abnormal. A roentgen examination will invariably disclose an abnormal shadow in the lung-field.

The roentgen characteristics depend on the region involved and the extent of the lesion. In the lateral position the abnormal shadow will overlap the heart or spine, or both, depending on the extent of the area involved. In diaphragmatic pleurisy the diaphragm is found elevated and its outline is more or less irregular as a result of a fibrinous deposit.

CHARLES G. SUTHERLAND, M.D.

Partial Pulmonary Atelectasis: A Post-operative Complication. A. Taylor and C. Zweifel. Fortschr. a. d. Geb. d. Röntgenstr., 1934, **49**, 157–161.

Two cases of partial pulmonary atelectasis are reported, with emphasis on the resulting mediastinal shifting. The symptomatology of this condition has attracted little attention in the German literature, while it is well established in English and American medicine.

HANS A. JARRE, M.D.

THYROID (DIAGNOSIS)

The Influence of the Thyroid on the Skin Reaction for X-rays of Medium Hardness. F. Ellinger. Strahlentherapie, 1933, **48**, 97–102.

In rabbits, following thyroidectomy, the skin reaction on the ear occurred much slower than was the case with normal animals. Irradiation was produced at 100 K.V., 4 ma., and filtered through 2.0 mm. Al (half value layer in Cu 0.16 mm.). Doses of 150 and 700 r were used.

ERNST A. POHLE, M.D., Ph.D.

THYROID (THERAPY)

X-ray Treatment of Exophthalmic Goiter. Charles S. D. Don. Brit. Med. Jour., April 28, 1934, No. 3825, 746–748.

The author discusses the x-ray treatment of exophthalmic goiter in a series of cases which have been under observation for a minimum period of one year. The results of this form of therapy were determined by a study of the variation in the weight, the basal metabolic rate, the pulse rate, the patients' symptoms and signs, and their own opinion as to the value of the treatment.

In the treatment of these cases two areas were treated, at first twice a week, then once a week, and thereafter with increasing intervals between treatments as the patient improved. The following factors were employed: 6.5 inch spark gap, 3 milliamperes, 3 mm. aluminum filter, time, 5 minutes. With the apparatus employed, this exposure was equal to a half Sabouraud pastille dose. Rest and a nourishing diet were insisted upon, but iodine was not prescribed.

The cases in this series were divided into "cure," "improvement," and "failure." Of the 103 patients beginning treatment, 10 discontinued it during the first three months, and were treated by surgery. It was impossible, therefore, to classify these ten cases, because of lack of sufficient time to determine the results of x-ray therapy. Of the remaining 93 cases, at the end of six months' treatment seven had been operated on, and at the end of a year six more had been referred for surgery. At the end of the two-year period seven additional patients were operated on, and at the end of three years, one additional patient was treated by surgery. The author is of the opinion that these cases referred to surgery after the six-month period cannot all be classified as failures for a considerable number showed improvement. Of the seven patients referred for surgery after six months of x-ray therapy, four were classed as failures, and three were listed as "improvement." Of the six operated on at the end of a year, five were classified as "failure" and one as "improvement." The final results are: Cure, 38; improvement, 30; failure, 25.

While it was noted that recurrences and relapses may occur in those patients considered cured, it was also observed that the percentage of cures and improved cases was higher in a series of cases treated for more than one year than in a series treated for only one year. The author is of the opinion, therefore, that the extension of x-ray treatment beyond one year, when necessary, is justified, as some cases do not reach their maximum improvement at the end of one year. The reported series is made up from the working classes, and, therefore, it was the aim to obtain satisfactory results in one year. The author believes that this wish, plus the low surgical mortality rate experience in his hospital, probably accounts for the fact that a greater number of cases were operated on than Dr. Murray found necessary in his cases. Murray found surgical treatment advisable in about one-twelfth of the cases of his series treated by the x-rays.

J. N. ANÉ, M.D.

Roentgen Therapy of Basedow's Disease. Franz Bardachzi. Strahlentherapie, 1934, **49**, 618–633.

The author first reviews briefly the history of radiation therapy in Basedow's disease. It appears that small doses are advisable in the beginning, in order to avoid severe reactions due to a sudden increase of

secretion. Normal thyroid tissue is apparently not very radiosensitive, but the pathologic thyroid responds readily to 40 r. According to Schwarz, following irradiation the nervous symptoms are improved in 100 per cent, tachycardia in 65 per cent, increase in weight occurs in 65 per cent, the exophthalmos disappears in 37 per cent, and the struma reduces in 20 per cent. In favorable cases, relief may be expected in from 10 to 30 days after the treatment has been started: the objective symptoms should improve within from 3 to 4 weeks. Some radiologists use two small fields over each lobe of the thyroid and an additional thymus field. It seems best, however, to apply one large frontal area at 50 cm. distance. An initial dose of 60 r seems to be safe; a total of from 1100 to 1600 r administered in from 12 to 24 weeks is sufficient to bring about results. Opponents of irradiation claim a high mortality for roentgentherapy, and also point to a marked fibrosis after treatment, thereby rendering a future operation difficult. There is nothing in the literature to support the first claim, and the fibrosis can certainly be avoided with proper technic. The author recommends, therefore, trial of irradiation in all typical cases of Basedow's disease. If there is no improvement after from 2 to 3 months, operation seems advisable. Hyperthyroidism with pressure symptoms should as a rule be operated upon; the same holds true of toxic adenoma. In the latter group, patients who are inoperable because of severe toxic symptoms can often be made operable by irradiation.

ERNST A. POHLE, M.D., Ph.D.

The Roentgentherapy of Flajani-Basedow's Disease. Luigi Ferretti. Archivio di Radiologia, 1934, **10,** 50–71.

The author reports 12 cases of exophthalmic goiter which he treated with x-rays with a favorable result. He favors mild doses of from 15 to 20 per cent of an erythema dose, using 170 K.V., 2 ma., 0.2 Cu + 2 Al, at 31 cm. T.S.D., to be repeated every two weeks for five treatments. Following this treatment, there must be an interval of 40 days, after which the cycle is repeated and then a third time if indicated after from 6 to 8 weeks. Meanwhile, the patient is under careful medical supervision. The author feels that this method of treatment is of value in the great majority of cases.

E. T. LEDDY, M.D.

TUBERCULOSIS (DIAGNOSIS)

The Latent Period in the Roentgen Diagnosis of Pulmonary Tuberculosis: Preliminary Report. Leo G. Rigler and Frederick B. Exner. Jour. Am. Med. Assn., May 26, 1934, **102,** 1750–1754.

It is obviously most difficult to date actually the occurrence of a tuberculous infection in the human being. It is often possible to state with accuracy the time of onset of symptoms, but that may be long after the onset of the infection. Only one means of great accuracy is at hand, *i.e.*, the tuberculin skin test. The interval between the occurrence of the infection and the establishment of a positive skin test must be very short, probably only a few weeks or less. In the typical first infection tuberculosis, as seen in young children, the development may be very rapid, and the lesions are detected in the roentgenogram with ease because of their extensive character.

The authors have observed a number of cases of pulmonary tuberculosis developing in medical students and internes who have previously had repeated tuberculin skin tests, chiefly by the Mantoux method, and have also had repeated roentgenograms of the chest. In some they have been able to trace exactly the time of onset of the infection and the period of time that has elapsed before roentgen signs in the lungs became apparent. The roentgenogram, they conclude, is an exceedingly sensitive method of detecting pulmonary tuberculosis.

C. G. SUTHERLAND, M.D.

TUBERCULOSIS OF SKIN

Roentgen Therapy of Lupus. Karl Zieler. Strahlentherapie, December, 1933, **48,** 670–679.

X-rays are beneficial in the treatment of tuberculosis of the skin. However, they should be used, as a rule, only in connection with other therapeutic procedures. Small doses cannot be recommended. The author has seen good results with from 80 to 100 per cent E.D. (3 mm. Al, H.V.L. in Al, 4.0 mm.), given twice at an interval of from 6 to 8 weeks. This dose should not be repeated more than three times.

ERNST A. POHLE, M.D., Ph.D.

TUMORS (DIAGNOSIS)

The Roentgen Diagnosis of Renal Tumors. Thomas Canigiani. Fortschr. a. d. Geb. d. Röntgenstr., 1934, **49,** 128–135.

This paper reports comparison of excretion and retrograde (instrumental) pyelography in six cases of renal tumors. In these indigokarmin was excreted well by both kidneys but no excretion-urographic images were obtained of the involved kidneys, while typical filling deficiencies and deformities were shown by instrumenta' pyelography. The latter method is given preference for tumor diagnosis. The fallacy of good excretion of indigokarmin is emphasized and the lack of parallelism between excretion of dyes and excretion-urographic demonstrability is to be noted.

HANS A. JARRE, M.D.

TUMORS (THERAPY)

Study on the Tissue Respiration and Glycolysis in Obstetrics and Gynecology, Part V. Effects of X-ray

Irradiation to the Respiration and Glycolysis in the Tissues of Uterine Myoma. J. Toyoshima. Jap. Jour. Obstet. and Gynec., December, 1933, **16**, 531–534.

The author in his series of experiments on tissue respiration and glycolysis studied the effects of x-ray irradiation on these functions of the tissues of uterine myoma. The mechanism of the favorable results obtained by irradiation therapy on uterine myomas has not been settled as some investigators believe that there is a direct action on the cells of the tumor, and others are of the opinion that the action is indirect and results from disturbances produced in the ovarian tissues, which secondarily results in atrophy of the myomatous tissues.

The uterine myomas were removed by supravaginal amputation, were aseptically cut into pieces, and then washed repeatedly with aseptic Ringer's isotonic solution containing sugar. The portions of tissue were then cut into halves and one half was irradiated and the other half served as the control non-irradiated portion. The determination of the metabolism of these portions of tissue was obtained by means of the improved method of Warburg. The portions of tissue selected were irradiated immediately, employing the following factors: Filtration, 2 mm. Al and 0.5 mm. Zn; time, 28 minutes; minimum wave length, 0.076 Å.; surface dose, 310 r.

From the results of this experiment the author believes that the action of x-rays on uterine myomatous tissue is direct. It was found that the metabolism generally increased immediately after the irradiation. After this period the metabolism gradually decreased. The respiration as determined by the author showed no change during the first six days after irradiation, but decreased after the seventh day when compared to non-irradiated tissue. Anerobic glycolysis was slightly greater in the case of the irradiated tissue during the first seven days but was found to gradually decrease after the seventh day. Arobic glycolysis increased during the first seven days in the irradiated tissue when compared to normal tissue but the non-irradiated tissue showed a more marked acceleration.

J. N. ANÉ, M.D.

Study on the Tissue Respiration and Glycolysis in Obstetrics and Gynecology, Part VI. Effects of X-ray Irradiation to the Respiration and Glycolysis in the Tissues of Uterine Cancer. J. Toyoshima. Jap. Jour. Obstet. and Gynec., December, 1933, **16**, 534–537.

The author studied the effects of x-ray irradiation on the respiration and glycolysis of tissues of uterine cancer. The technic employed for the x-ray irradiation and determination of tissue metabolism was similar to that used by the author in his work on the irradiation of uterine myomatous tissues.

These experiments showed that uterine cancer is more radiosensitive than uterine myoma. The metabolism of the tissues of uterine cancer was found to be increased and then afterward greatly inhibited, following irradiation. Respiration increased after irradiation for the first three days, then gradually decreased. Arobic and anerobic glycolysis in the irradiated cancer tissue demonstrated a marked increase for the first five or six days, then a rapid decrease in these functions was noted.

J. N. ANÉ, M.D.